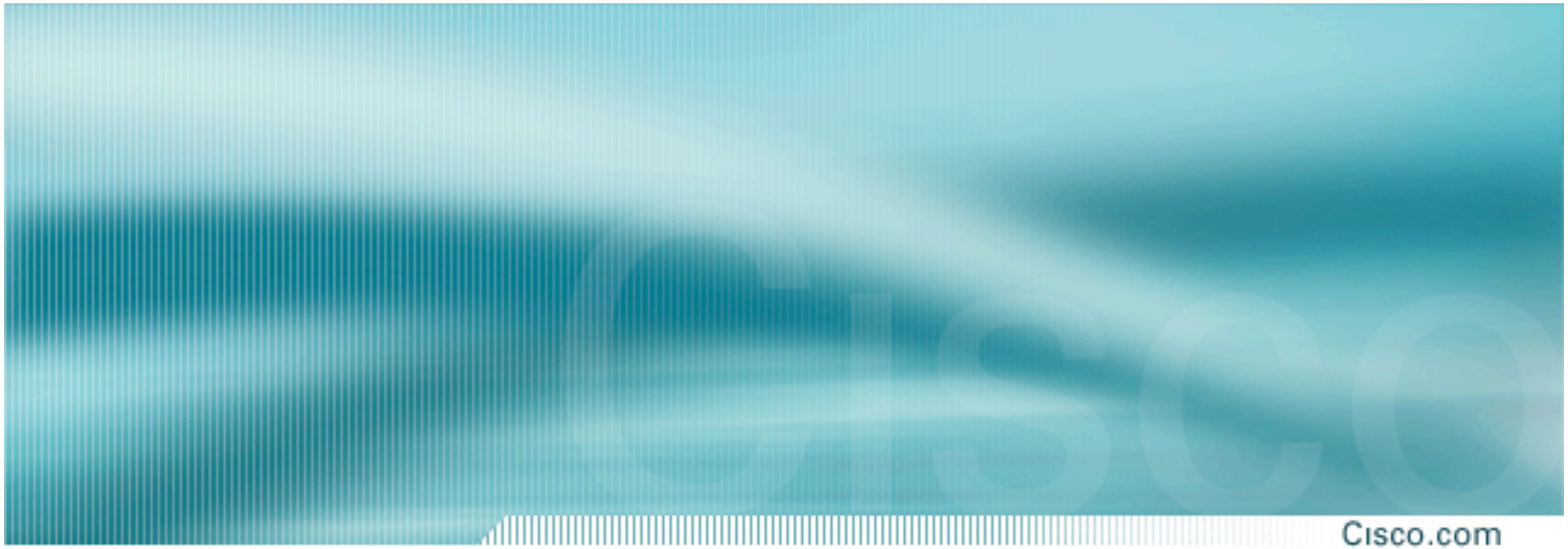


WAN Technologies

Based on
CCNA 4 v3.1 Slides
Compiled & modified by C. Pham

Wide-area Networks (WANs)

WANS are designed to:

- Operate over a large geographical area
- Allow access over serial interfaces operating at lower speeds
- Provide full-time and part-time connectivity
- Connect devices separated over wide, even global areas

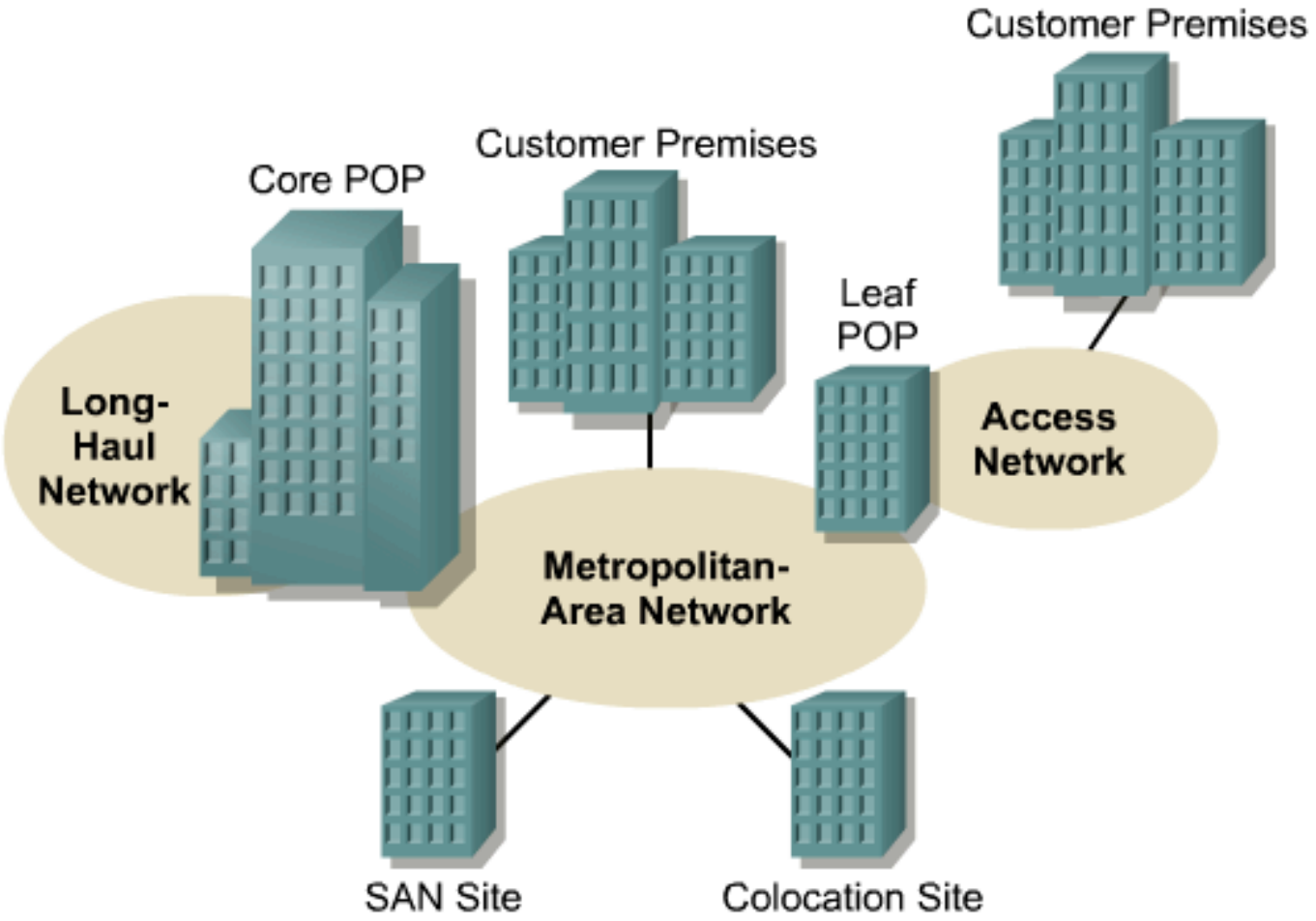
Using:

Router

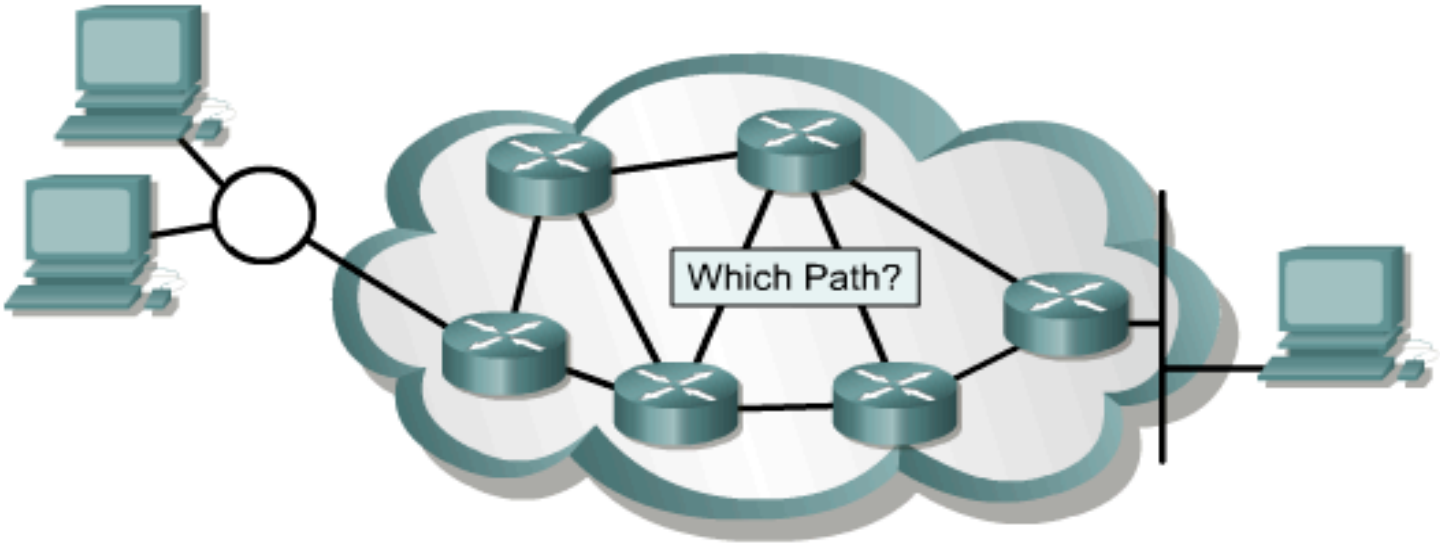
Communication Server

Modem CSU/DSU TA/NT1

Metropolitan-Area Network (MANs)



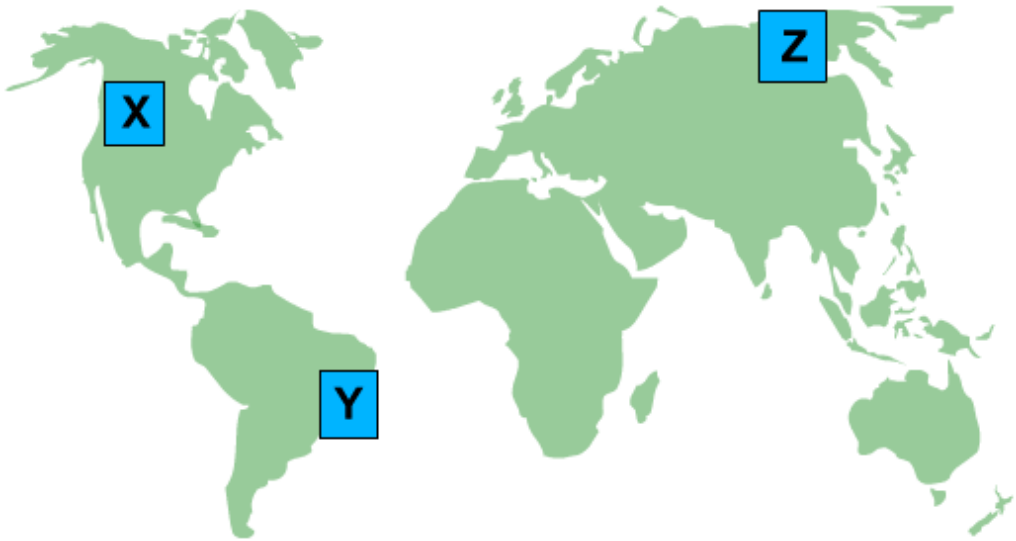
Path Determination



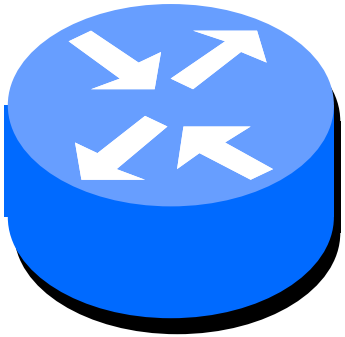
Layer 3 functions to find the best path through the internetwork.

Internetworking

- Any internetwork must include the following:
  - Consistent end-to-end addressing
  - Addresses that represent network topologies
  - Best path selection
  - Dynamic or static routing
  - Switching

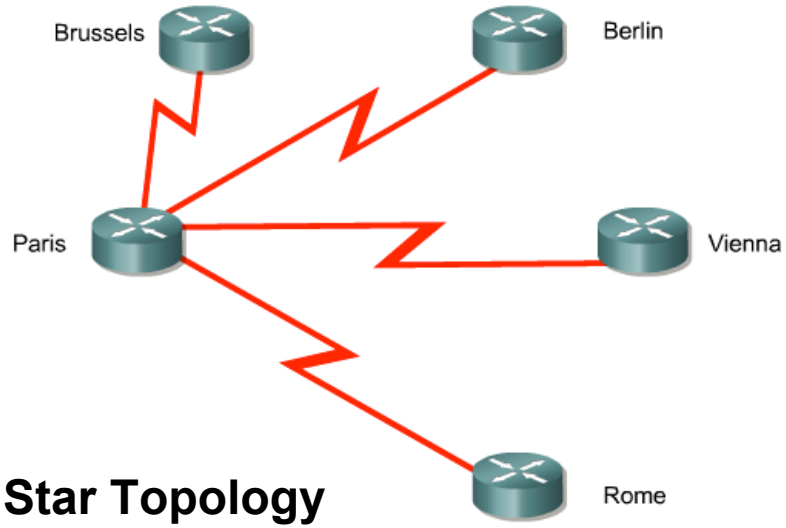


Router: core of WAN technologies

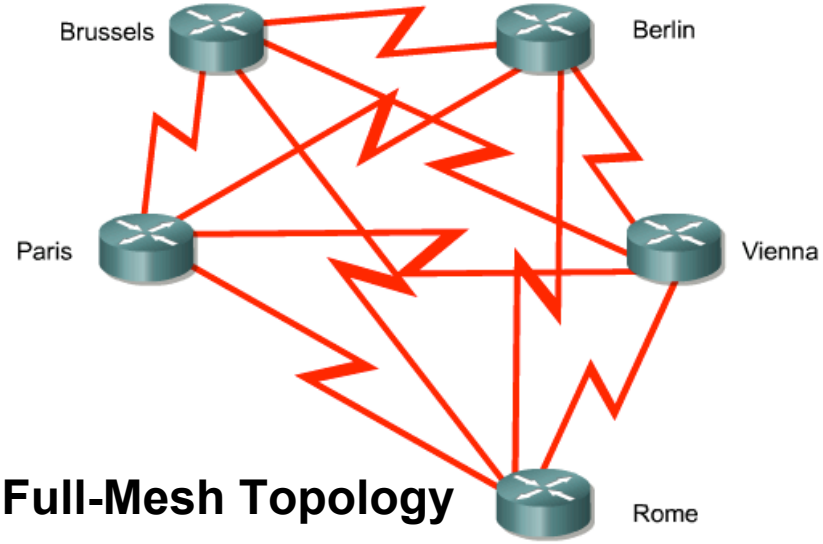


- **Routers send packets from one interface/network to another**

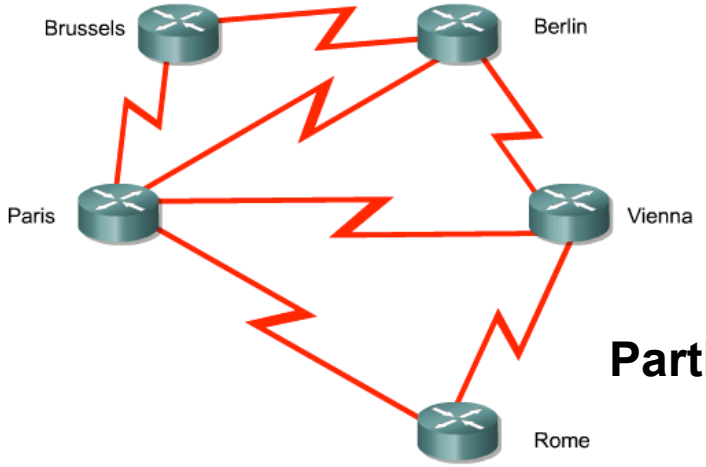
WAN Topology



Star Topology

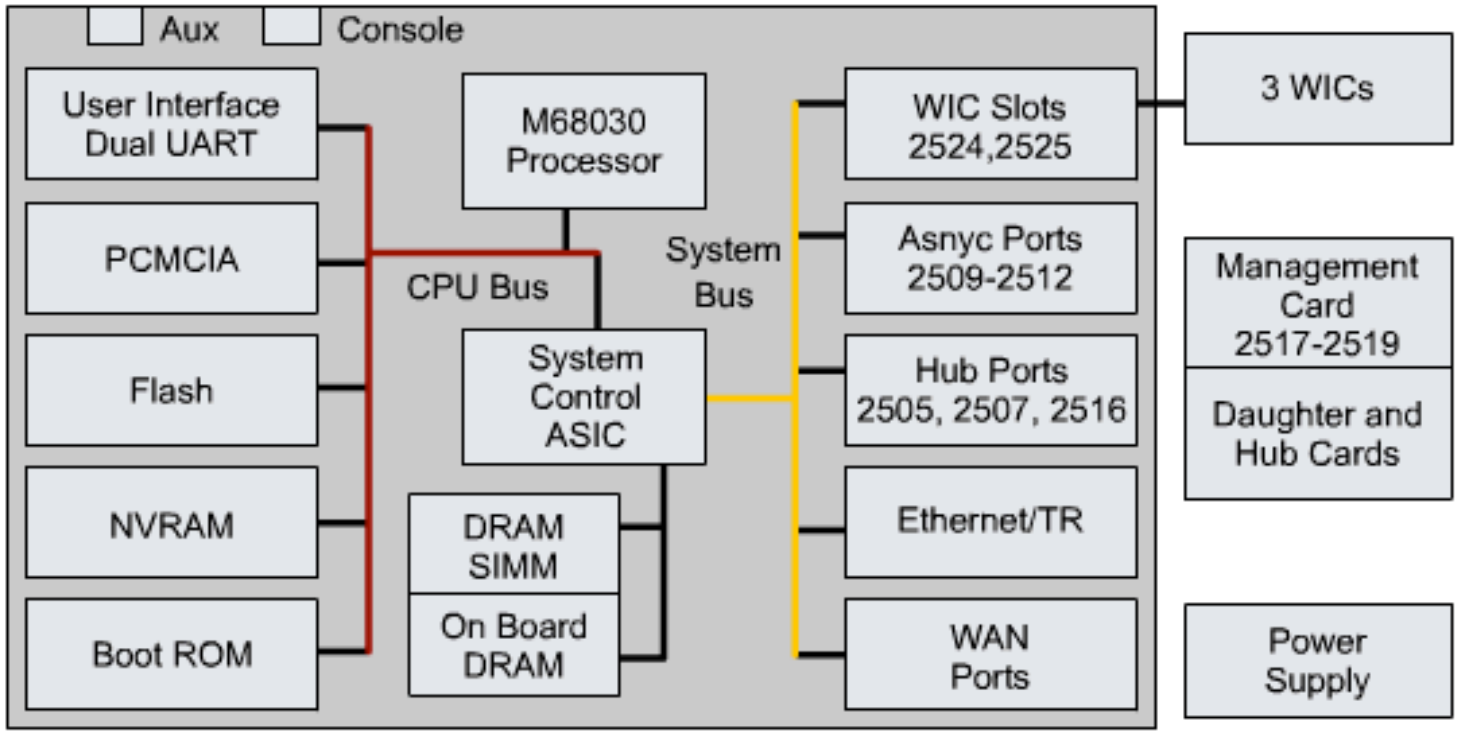


Full-Mesh Topology

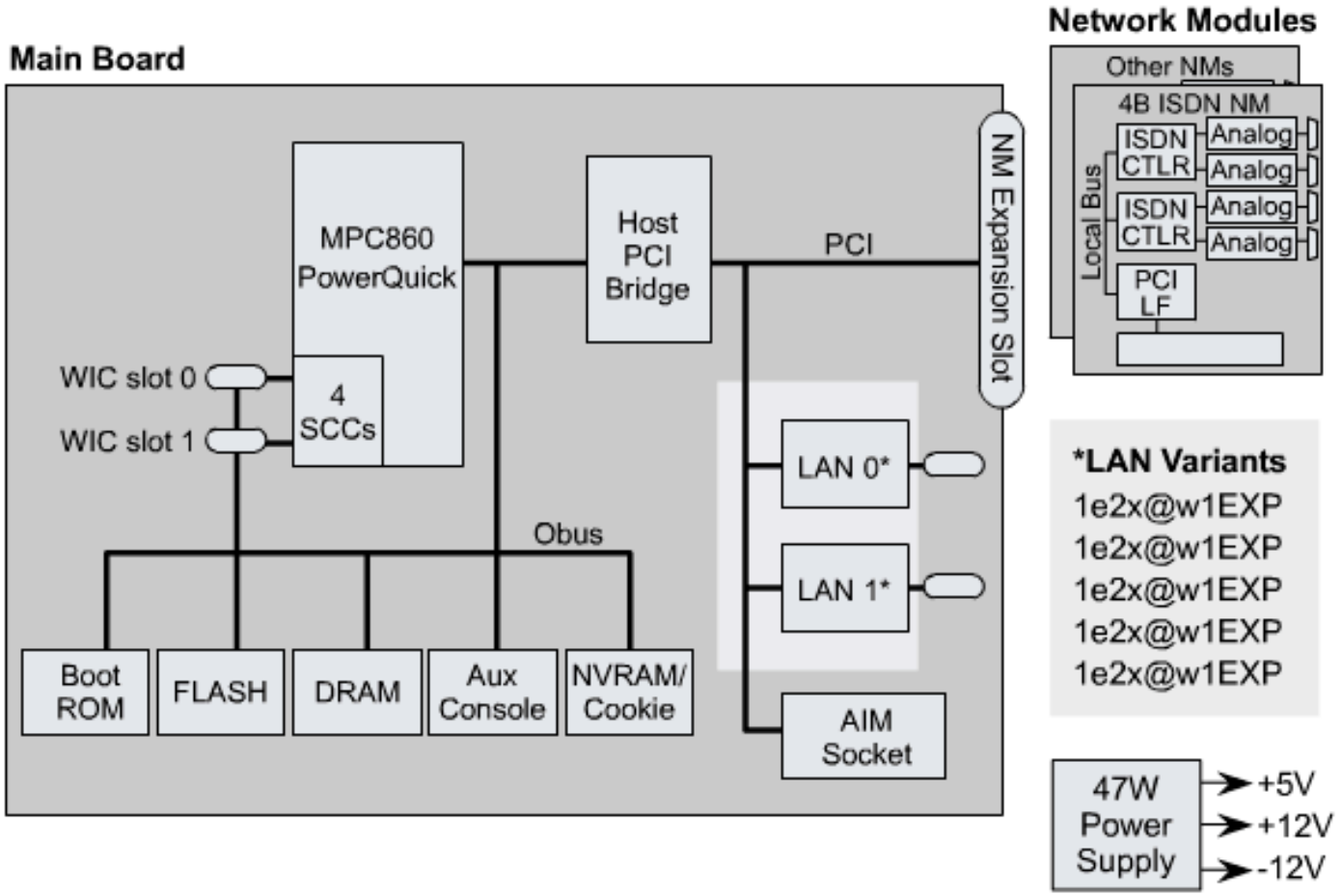


Partial-Mesh Topology

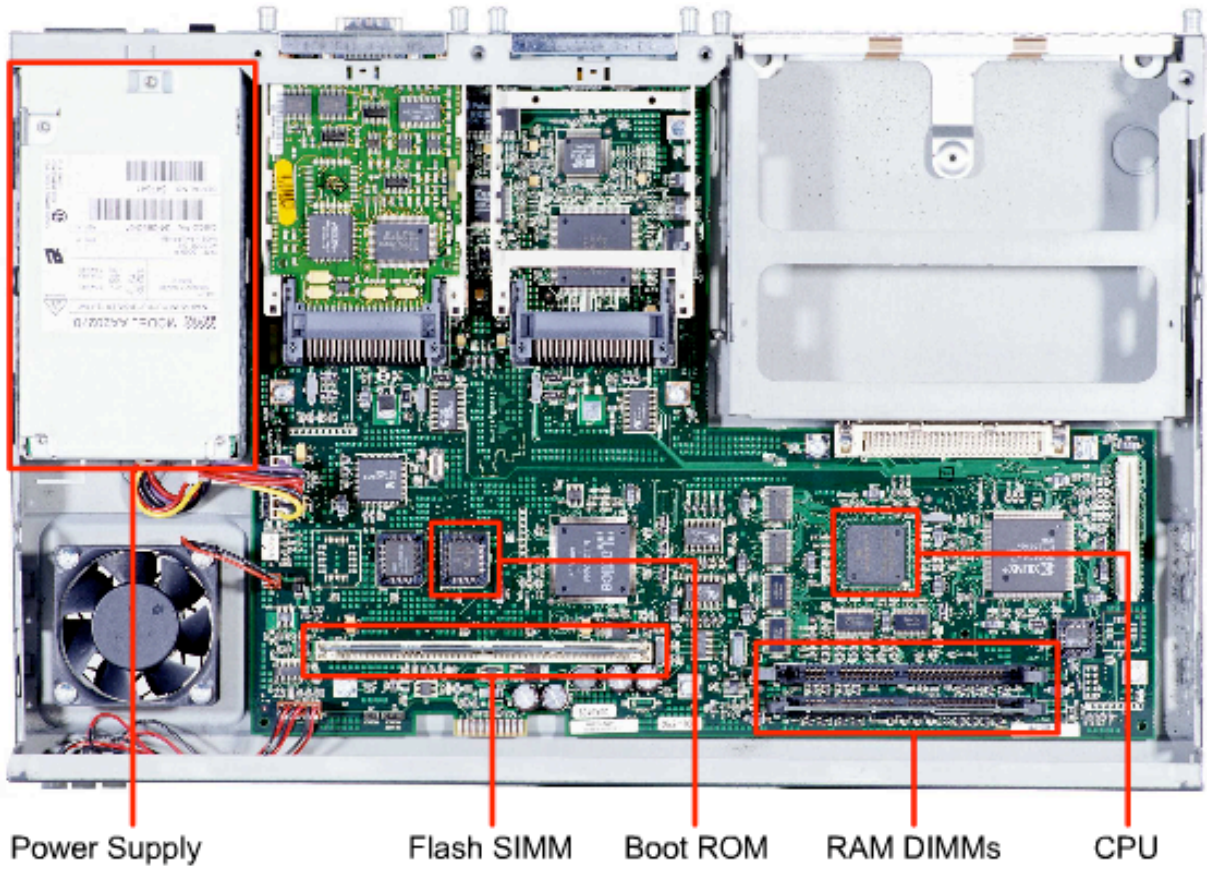
Router Internal Components



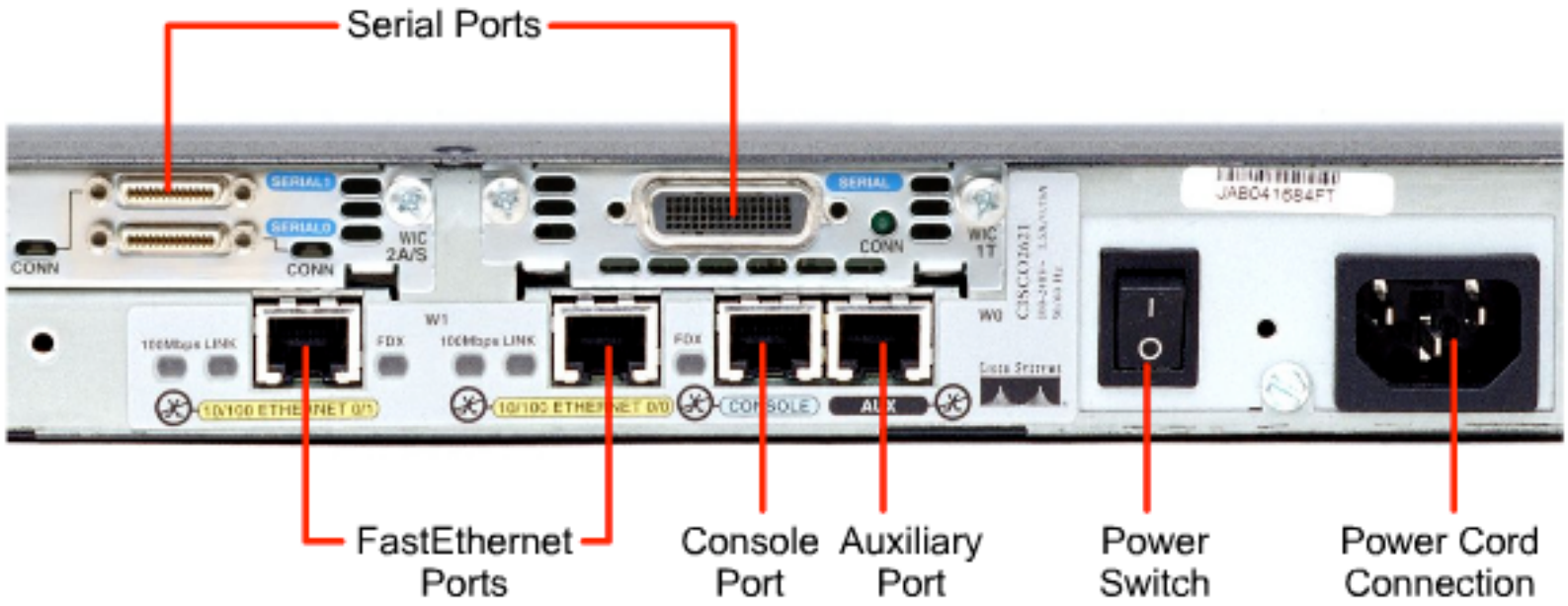
Router Internal Components



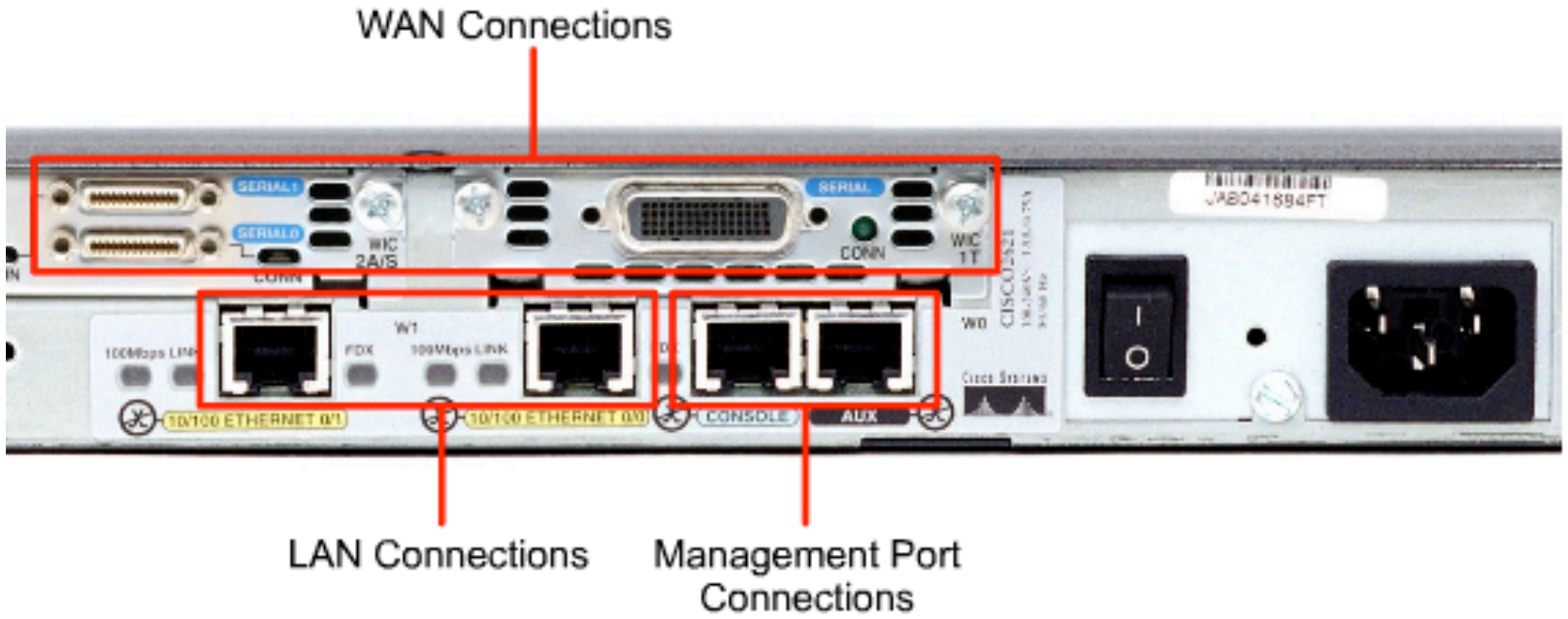
Internal Components of a 2600 Router



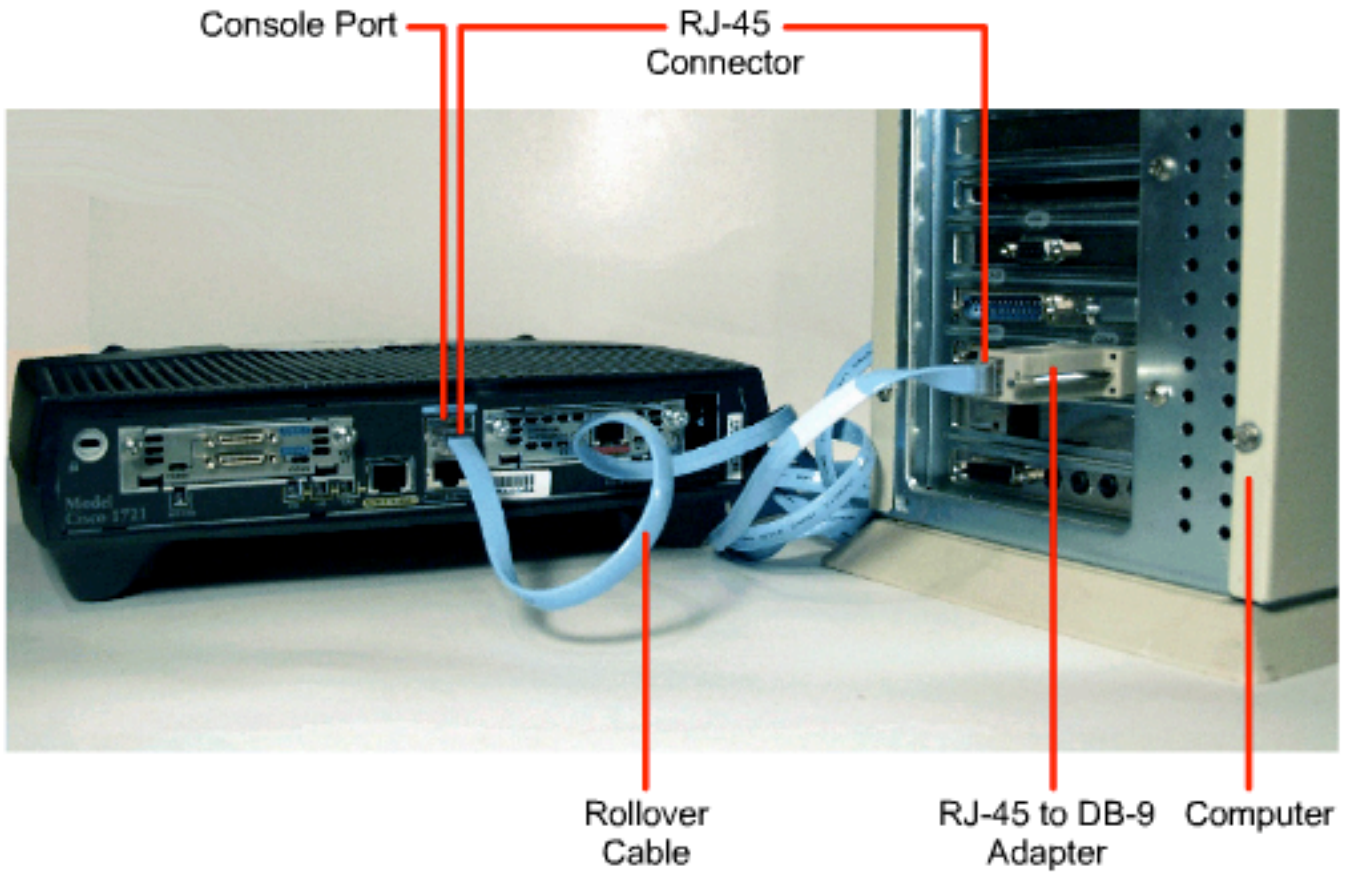
External Connections on a 2600 Router



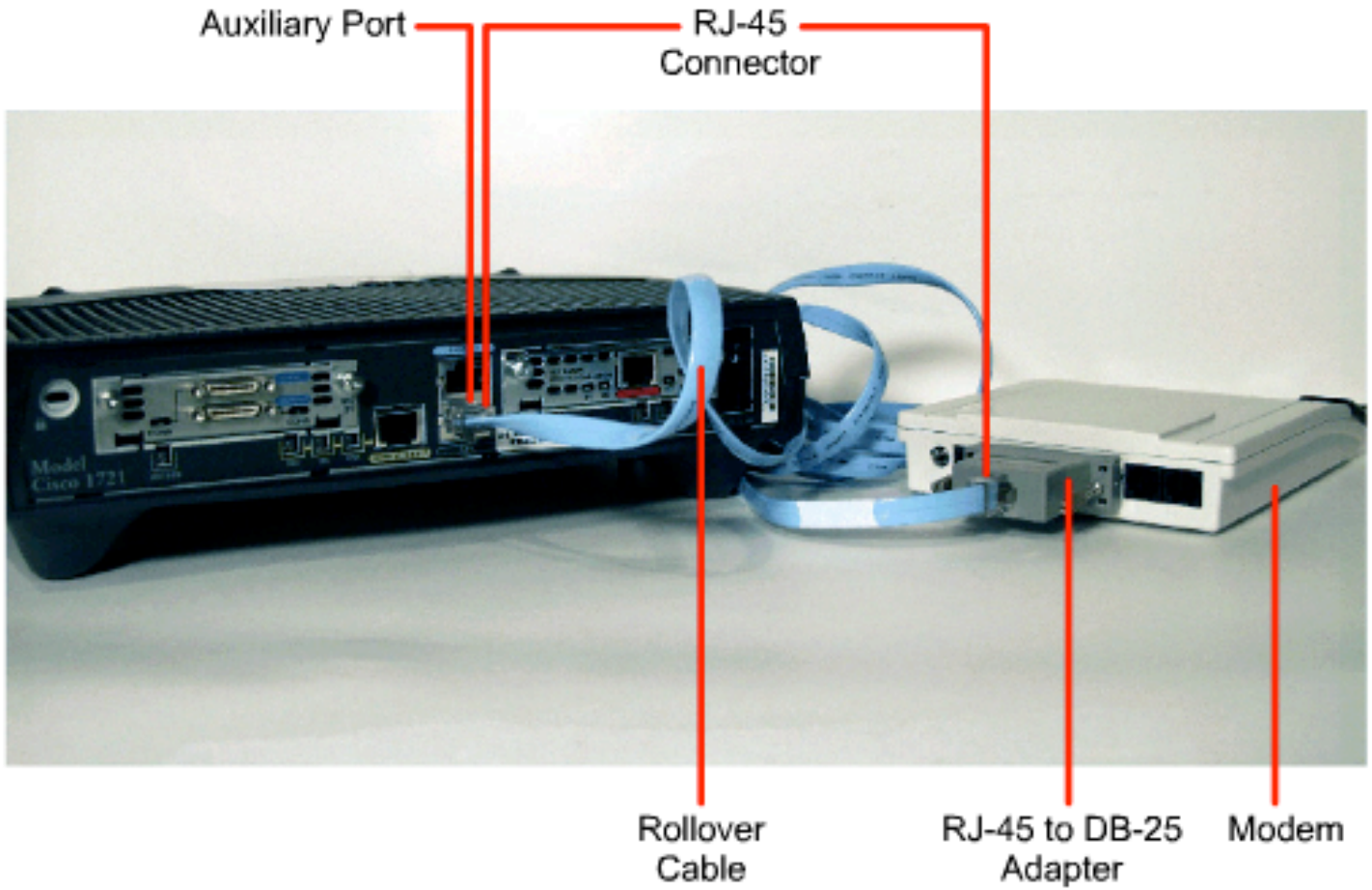
Router External Connections



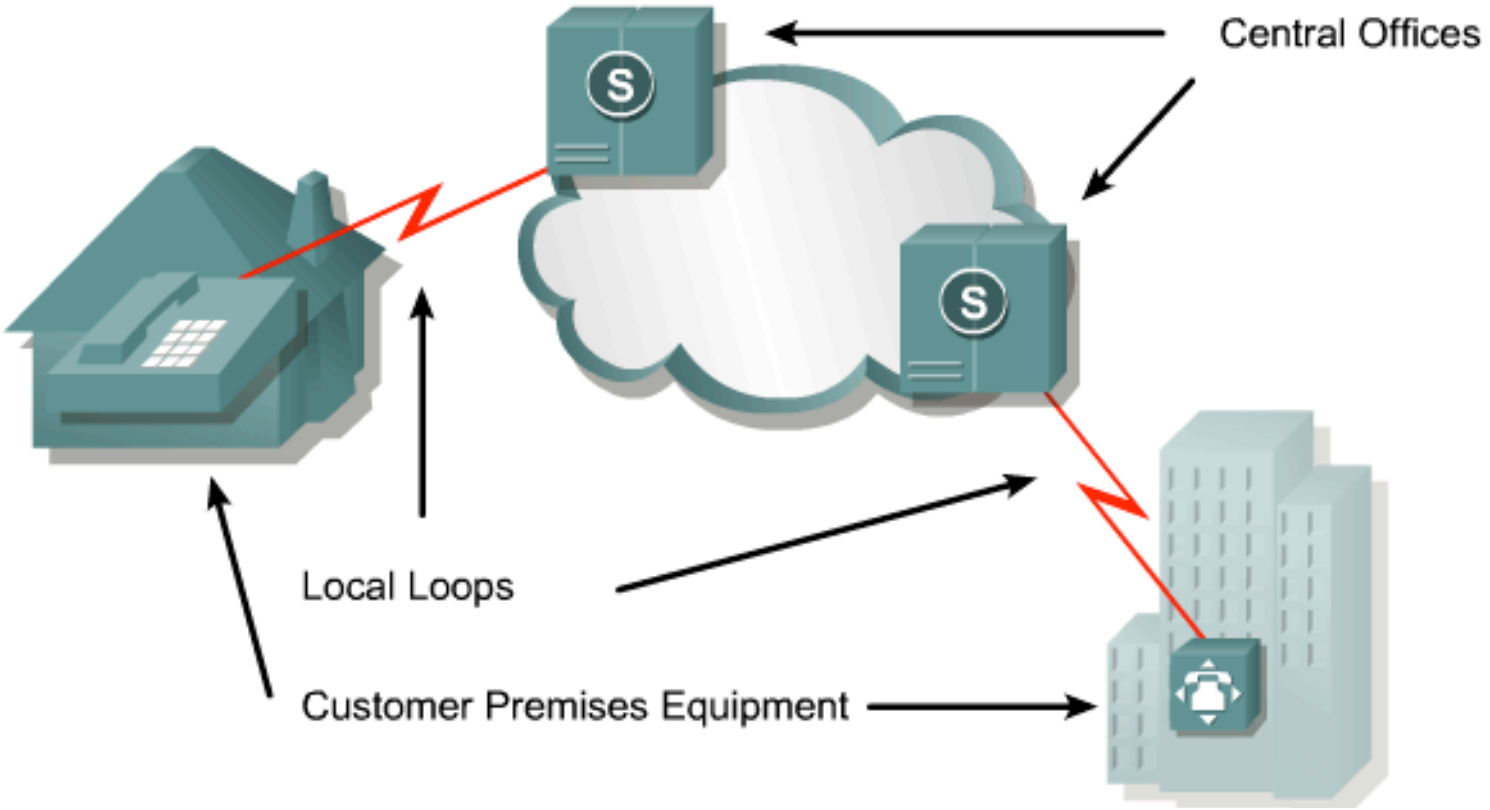
Computer or Terminal Console Connection



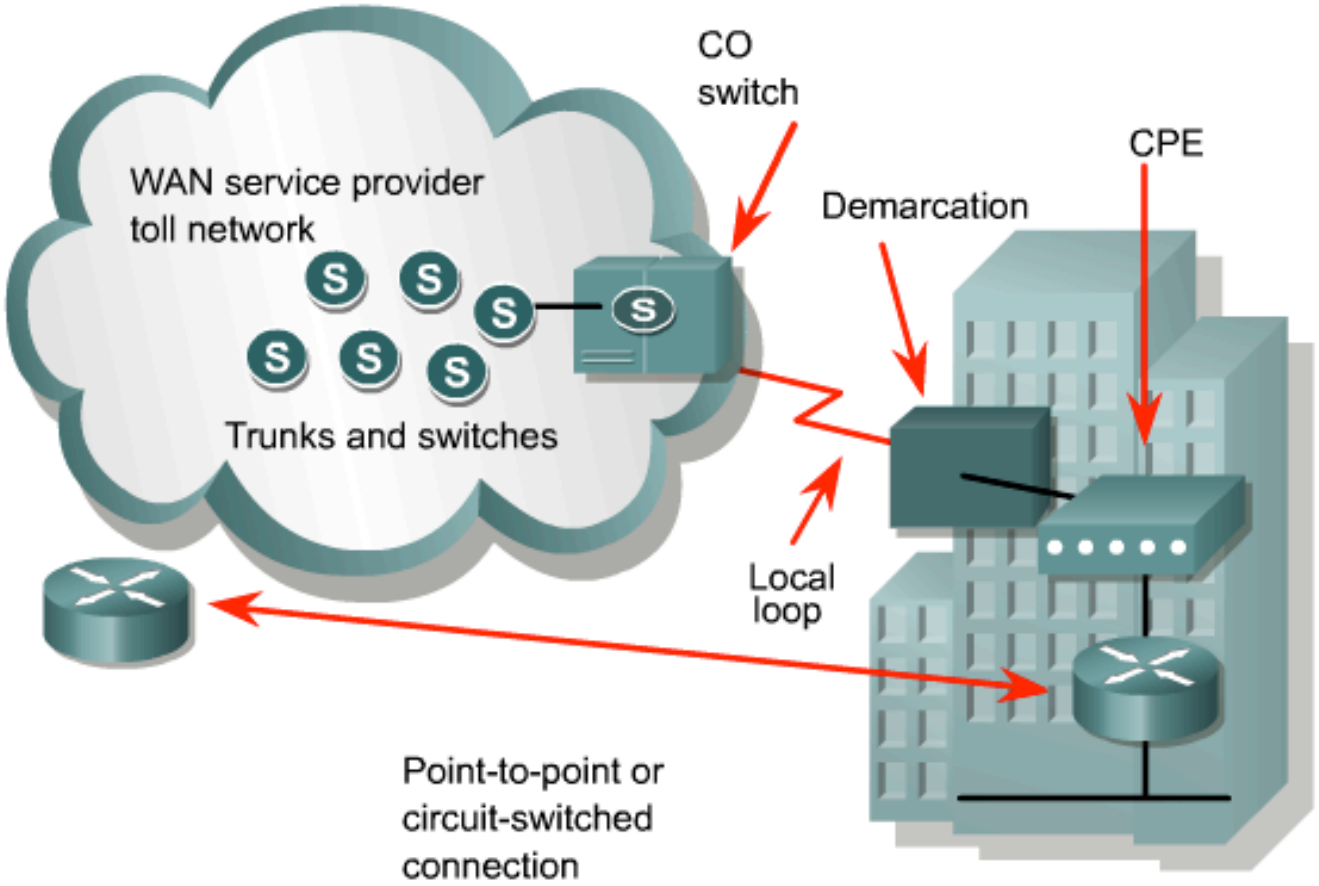
Modem Connection to Console or Auxiliary Port



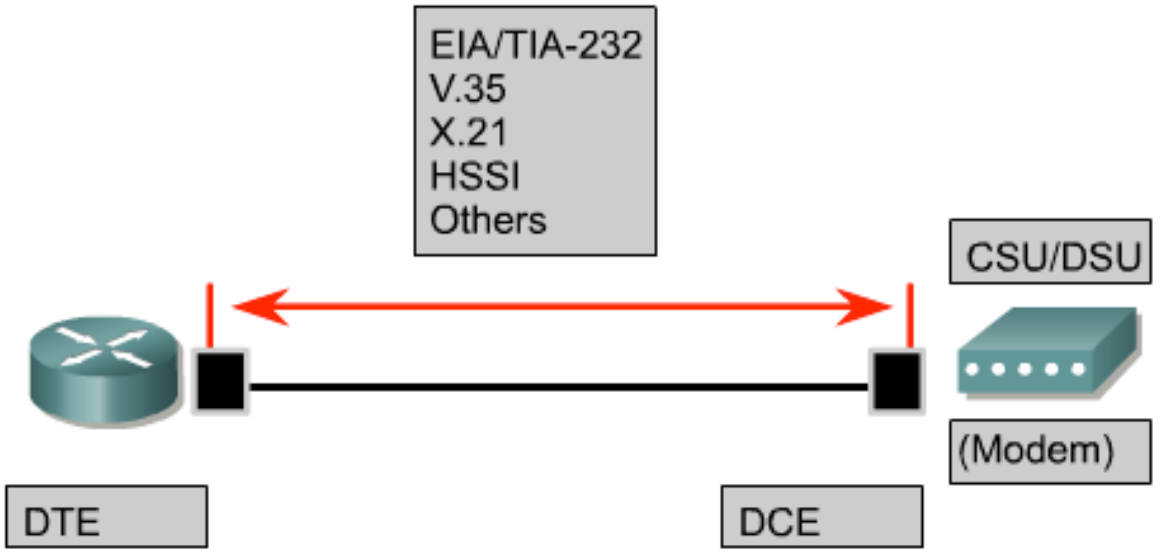
WAN Technology



WAN Service Providers



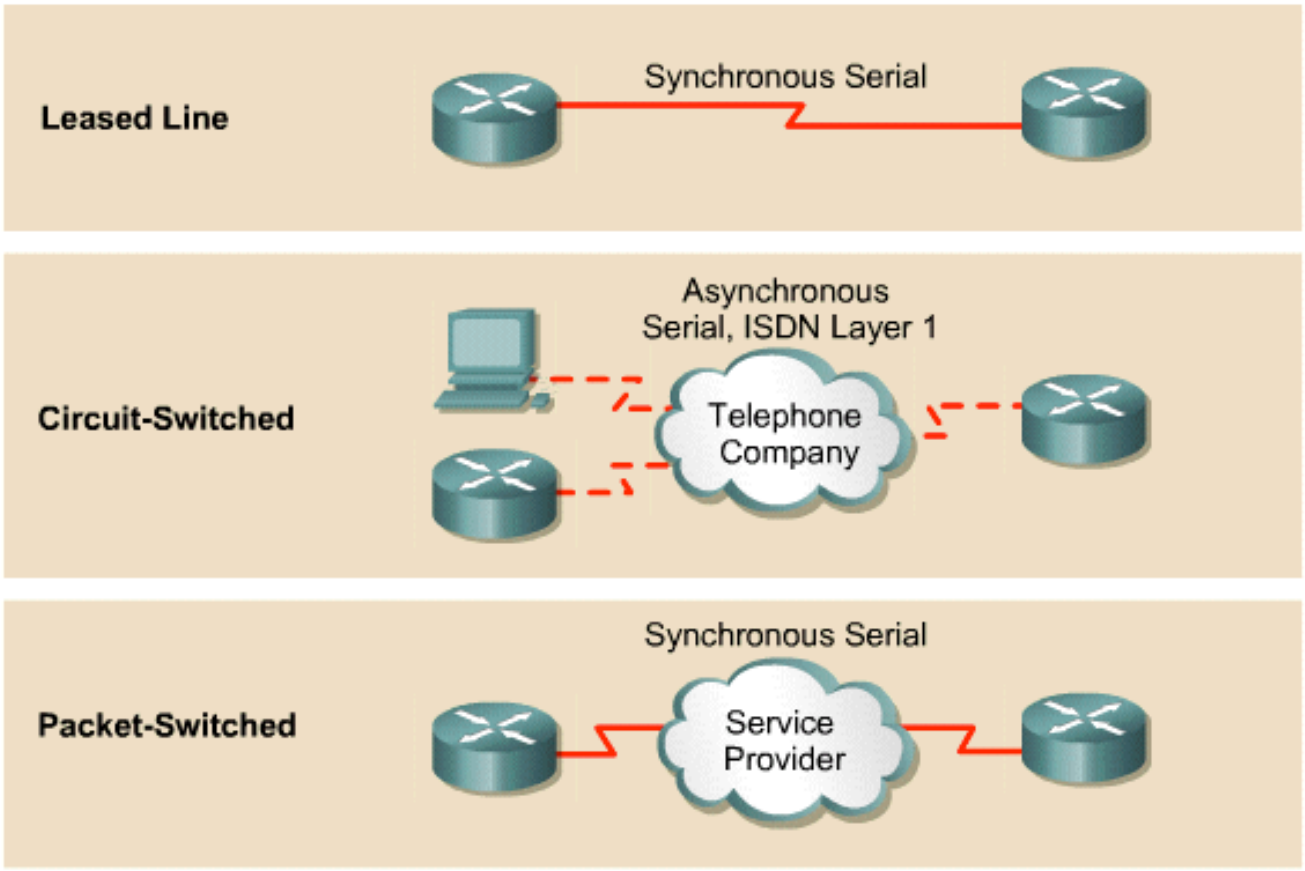
Physical Layer: WANs



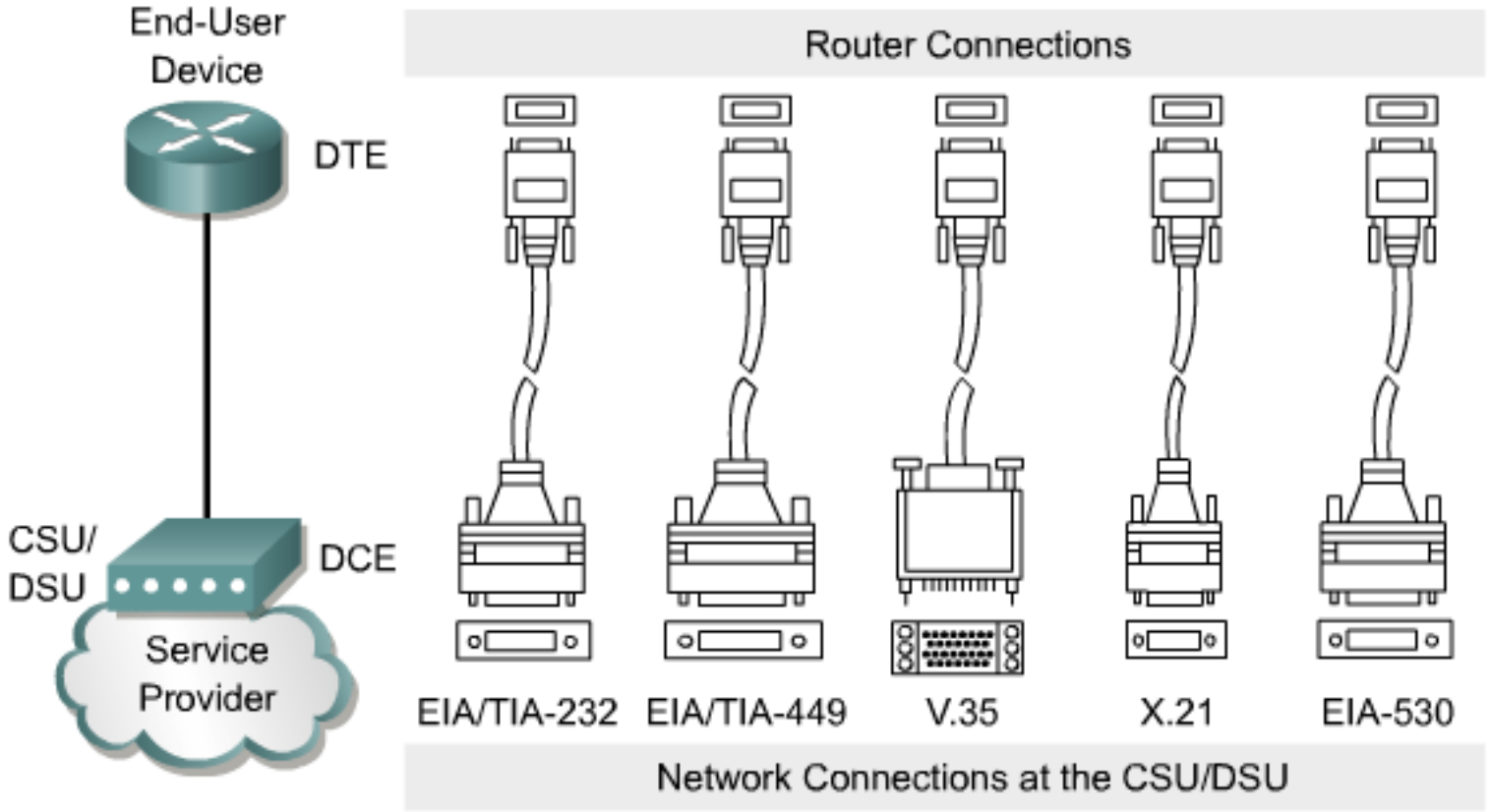
Data Terminal Equipment
User device with interface connecting to the WAN link

Data Circuit-Terminating Equipment
End of the WAN provider's side of the communication facility

WAN Types



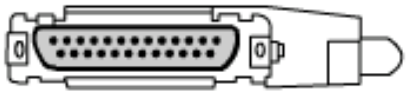
Router Serial WAN Connectors



DCE Serial Connections

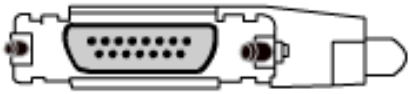
EIA/TIA-232 Male

EIA/TIA-232 Female



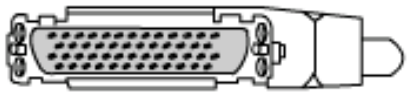
X.21 Male

X.21 Female

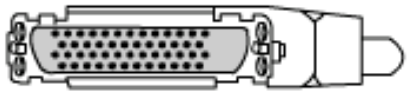


EIA-530 Male

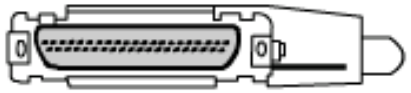
v.35 Male



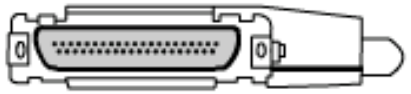
v.35 Female



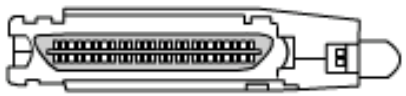
EIA/TIA - 449 Male



EIA/TIA - 449 Female



EIA-613 HSSI Male

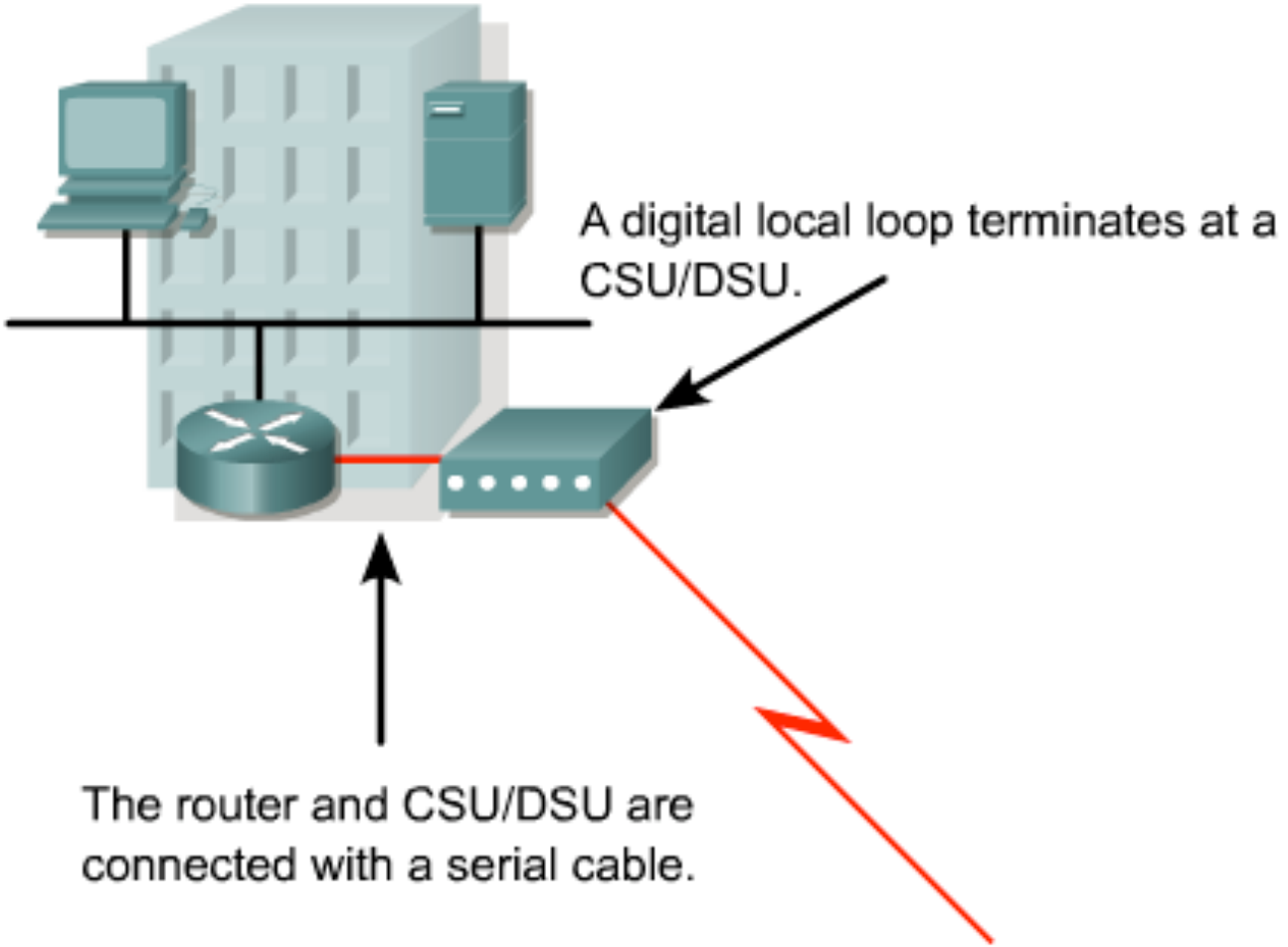


WAN Line Types and Bandwidth

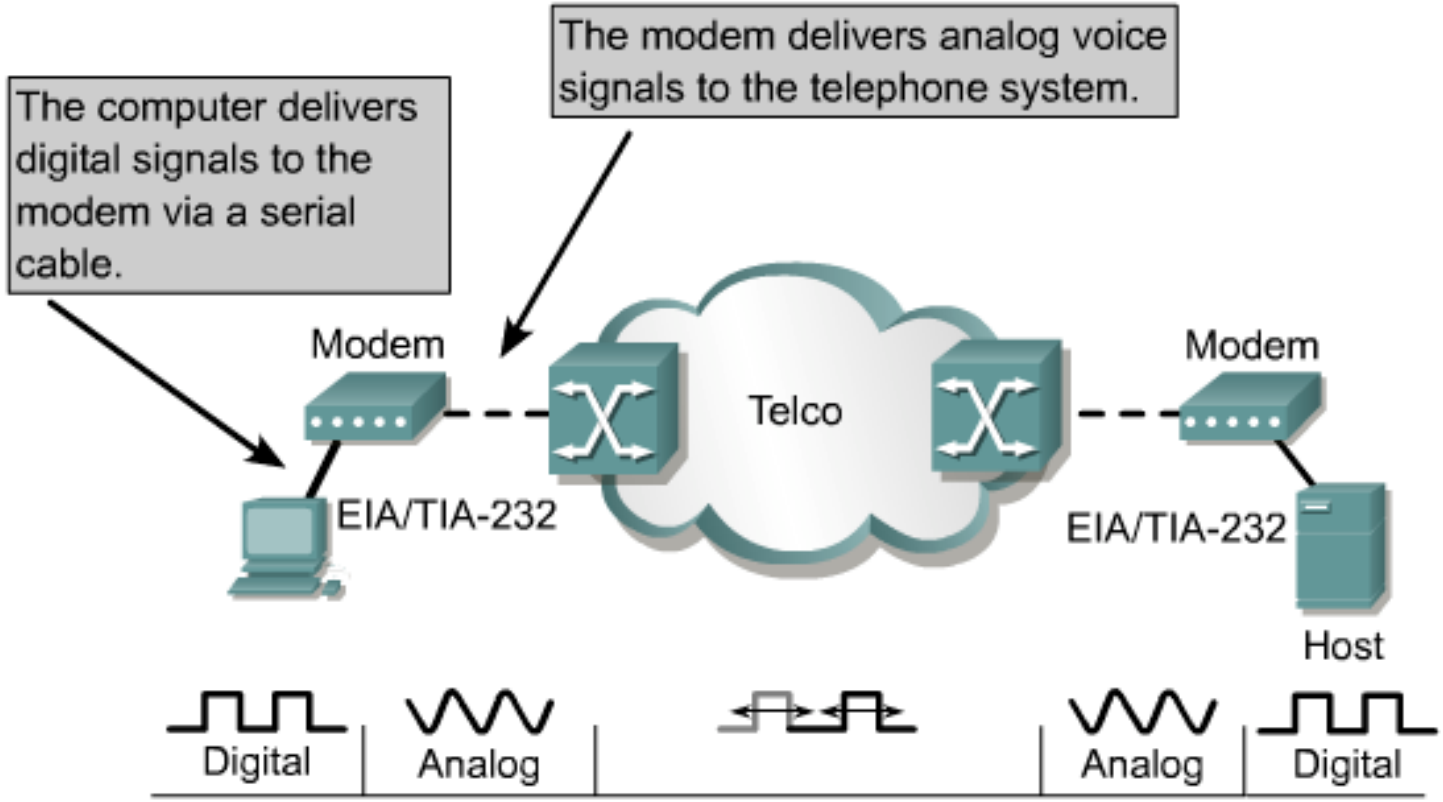
Line Type	Signal Standard	Bit Rate Capacity
56	DS0	56 Kbps
64	DS0	64 Kbps
T1	DS1	51.84 Mbps
E1	ZM	2.048 Mbps
E3	M3	34.064 Mbps
J1	Y1	2.048 Mbps
T3	DS3	44.736 Mbps
OC-1	SONET	51.84 Mbps
OC-3	SONET	155.54 Mbps
OC-9	SONET	466.56 Mbps
OC-12	SONET	622.08 Mbps
OC-18	SONET	933.12 Mbps
OC-24	SONET	1244.16 Mbps
OC-36	SONET	1866.24 Mbps
OC-48	SONET	2488.32 Mbps

CSU/DSU

Channel Service Unit/Data Service Unit.



Modem Transmission

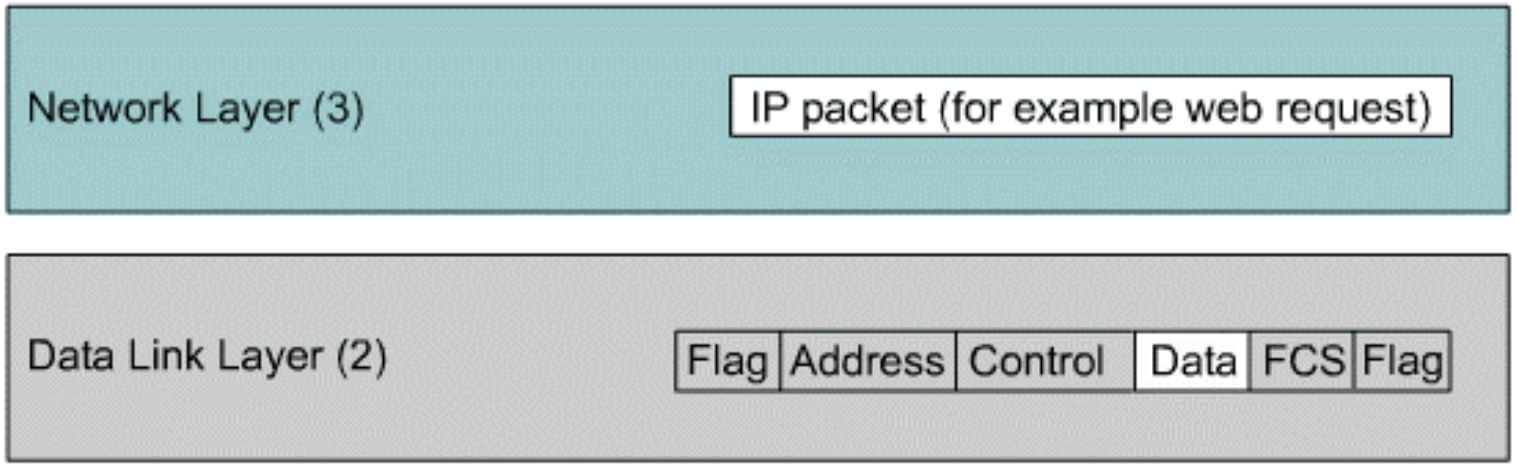


WAN Standards

Acronym	Organization
ITU-T (was CCITT)	ITU-T (was CCITT) International Telecommunication Union Telecommunication Standardization Sector, formerly the Consultative Committee for International Telegraph and Telephone
ISO	International Organization for Standardization
IETF	Internet Engineering Task Force
EIA	Electronic Industries Association
TIA	Telecommunications Industries Association

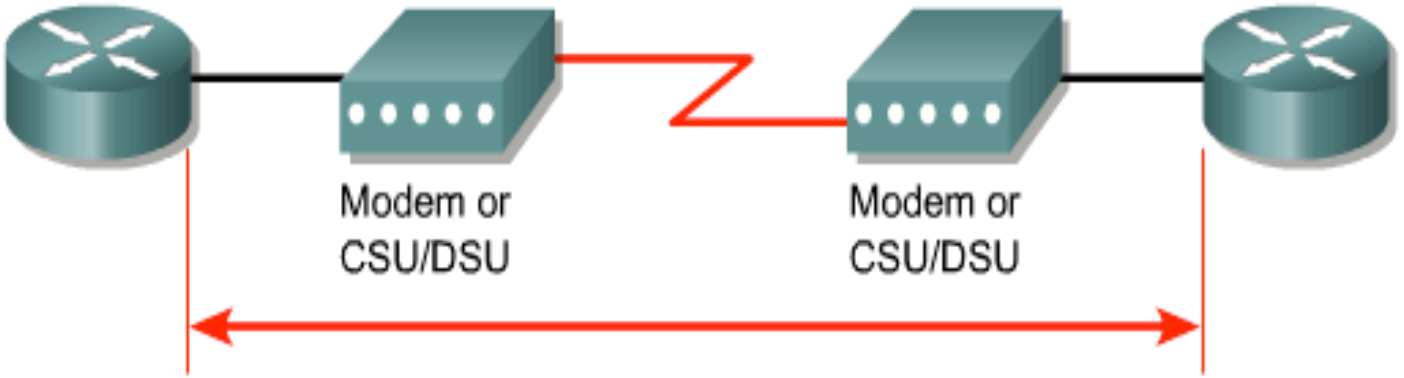
Standard	Description
ITU-T (was CCITT)	Allows signal speeds of up to 64 kbps on a 25 pin D connector over short distances. It was formerly known as RS-232. The ITU-T V.24 specification is effectively the same.
EIA/TIA 449/530	A faster (up to 2 Mbps) version of EIA/TIA 232. It uses a 36 pin D connector and is capable of longer cable runs. There are several versions. Also known as RS-422 and RS-423.
EIA/TIA 612/613	The High Speed Serial Interface (HSSI), which provides access to services at up to 52 Mbps on a 60 pin D connector.
V.35	An ITU-T standard for synchronous communications between a network access device and a packet network at speeds up to 48 kbps. It uses a 34 pin rectangular connector.
X.21	An ITU-T standard for synchronous digital communications. It uses a 15 pin D connector.

WAN Encapsulation



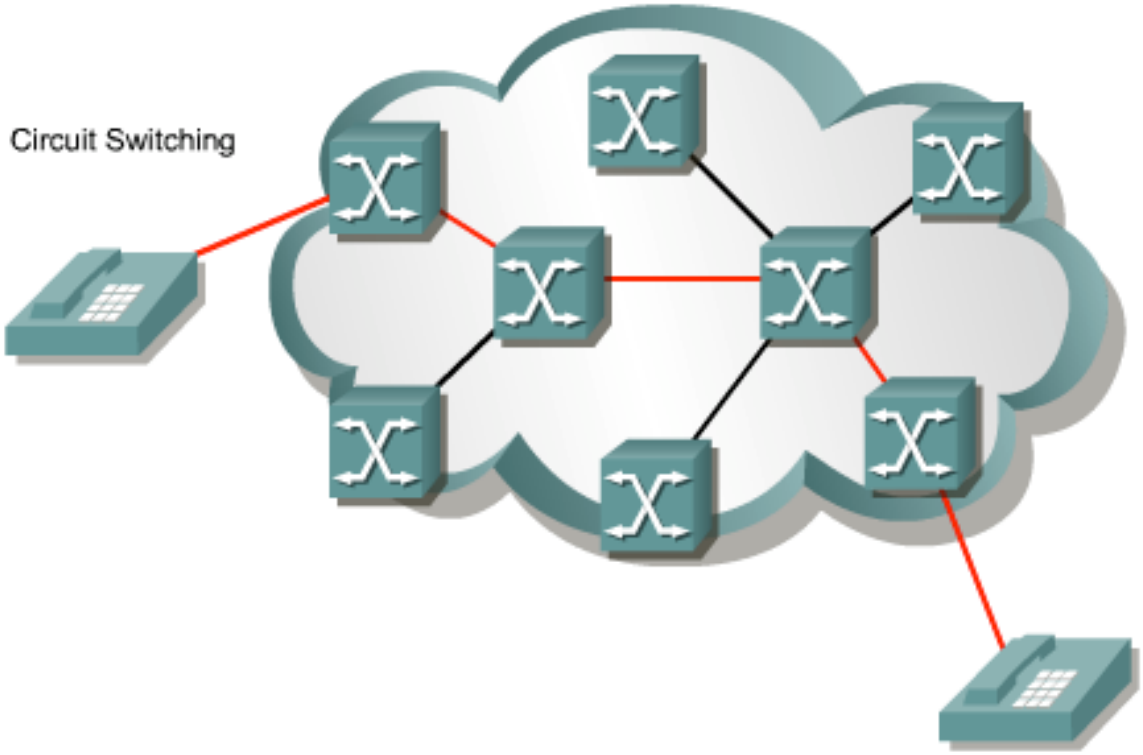
Network data is encapsulated in an HDLC frame.

WAN Data-Link Protocols



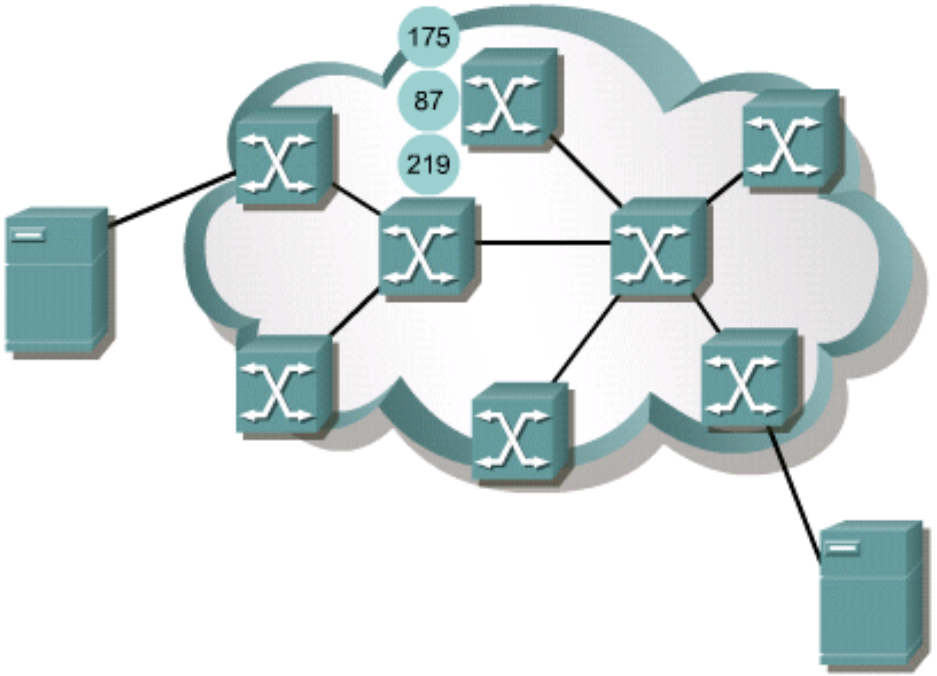
Protocol	Usage
Link Access Protocol Balanced (LAPB)	X.25
Link Access Protocol D Channel (LAPD)	ISDN D channel
Link Access Protocol Frame (LAPF)	Frame Relay
High-Level Data Link Control (HDLC)	Cisco's implementation has an extra header field
Point-to-Point Protocol (PPP)	Dialup connections

Circuit Switching



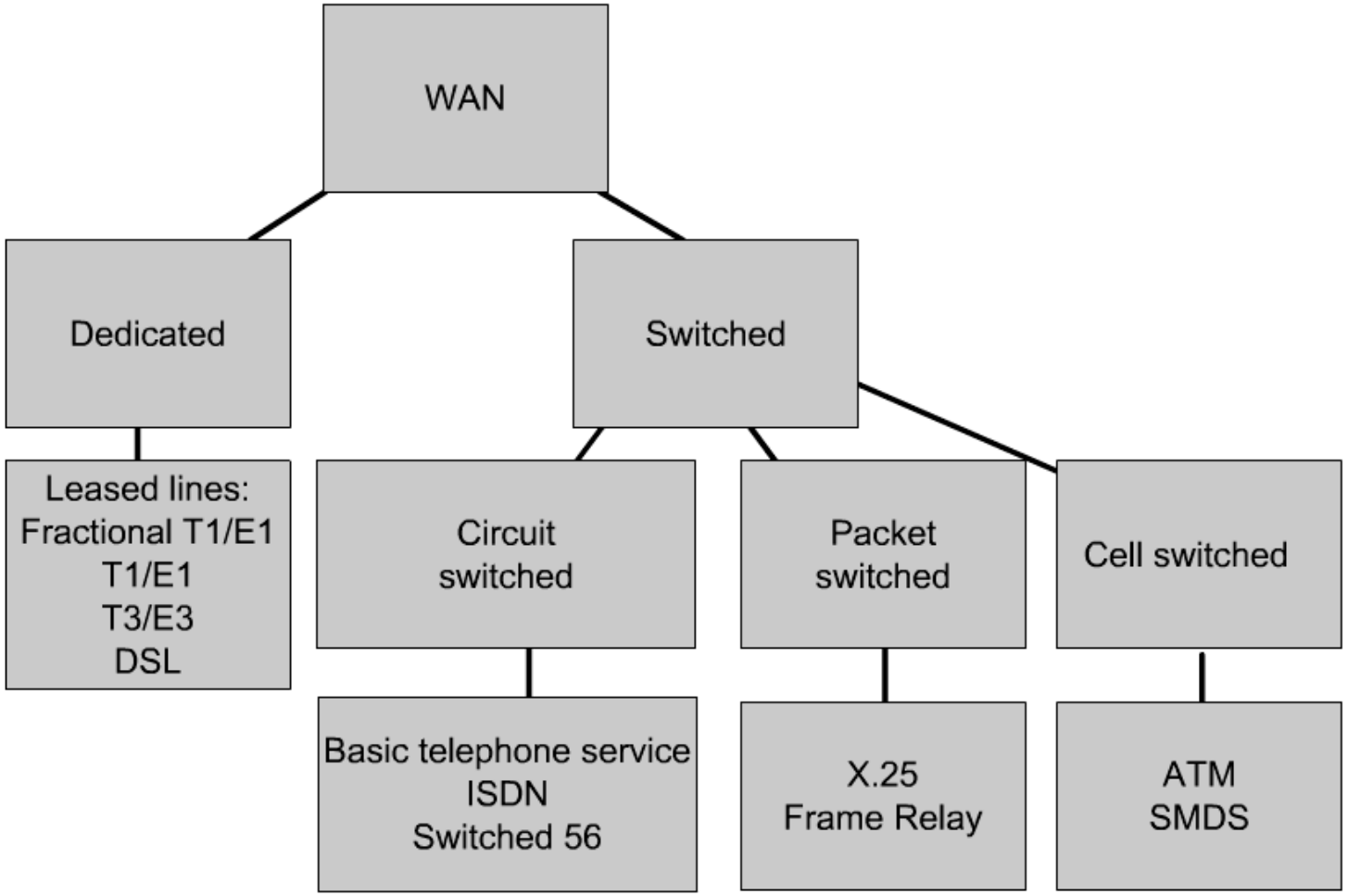
Dialing sets up a physical circuit through the system.

Packet Switching

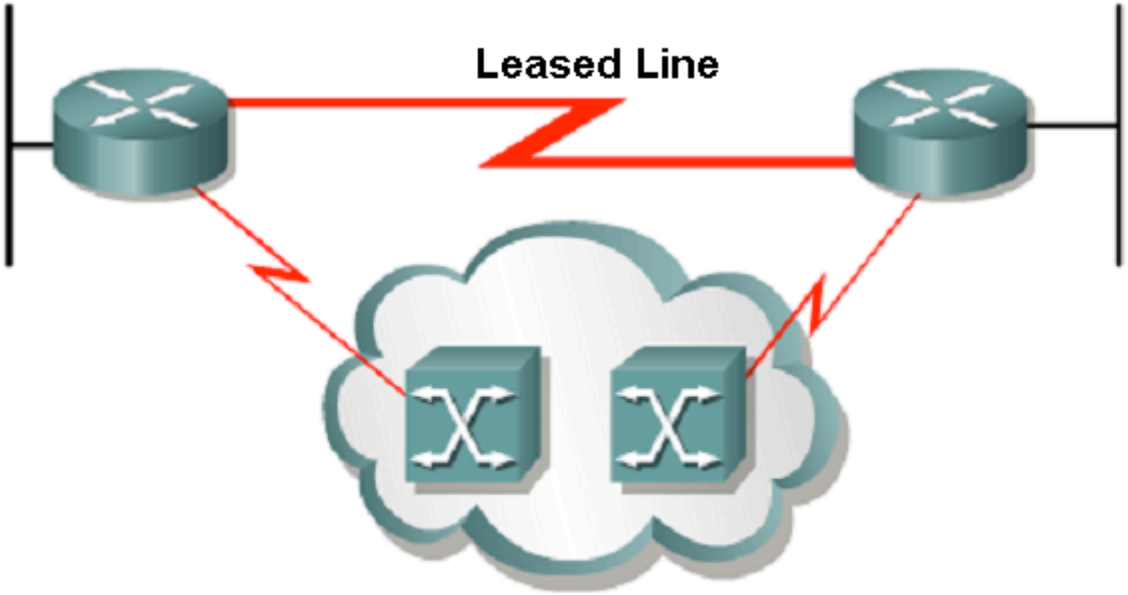


Labeled data is passed from switch to switch. It may have to wait its turn on a link.

WAN Link Options

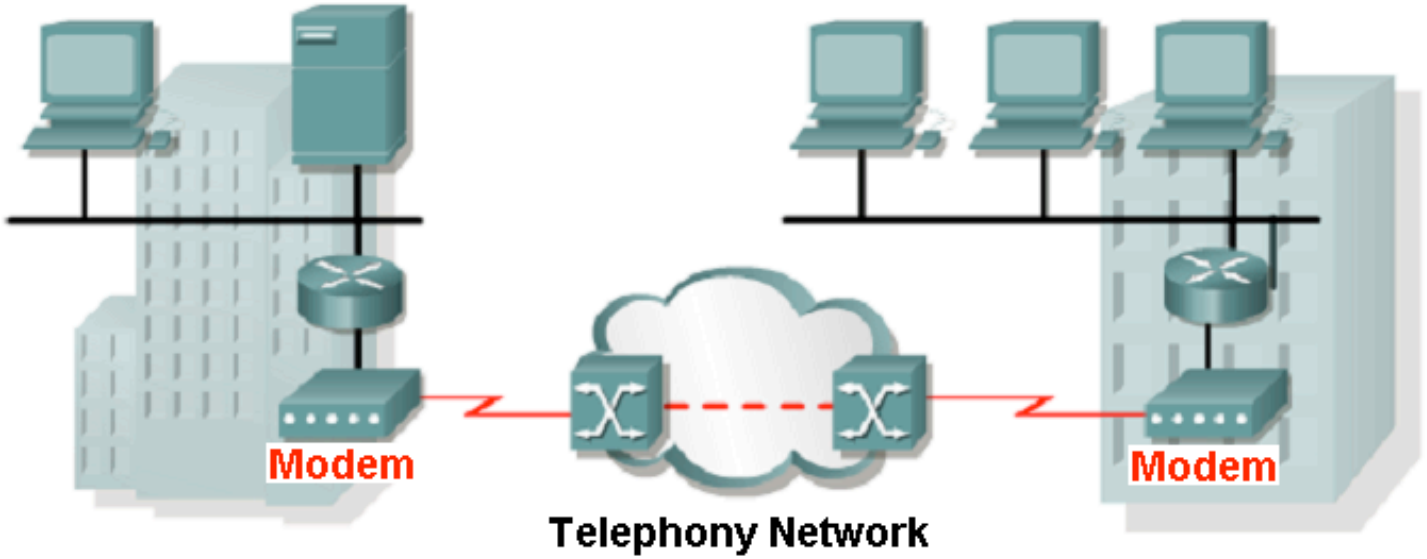


WAN Link Options



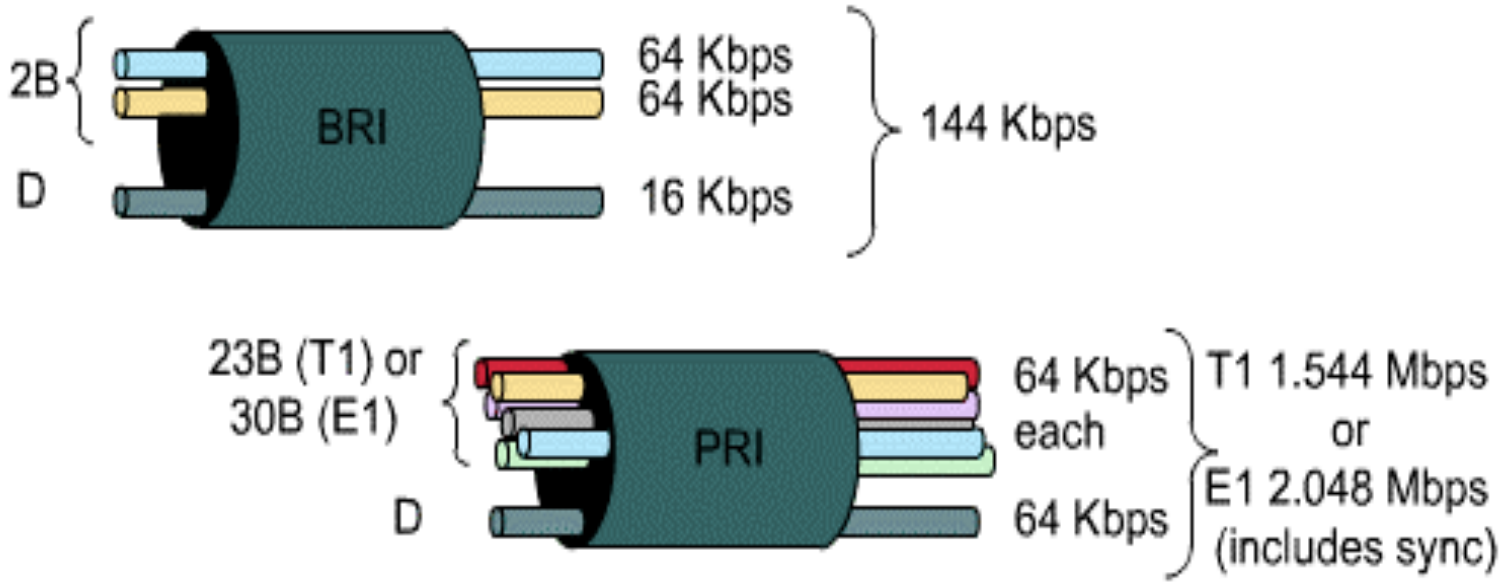
LANs can be connected with a long leased line or with shorter leased lines to a packet switched network. The packet network does the long haul.

Analog Dialup

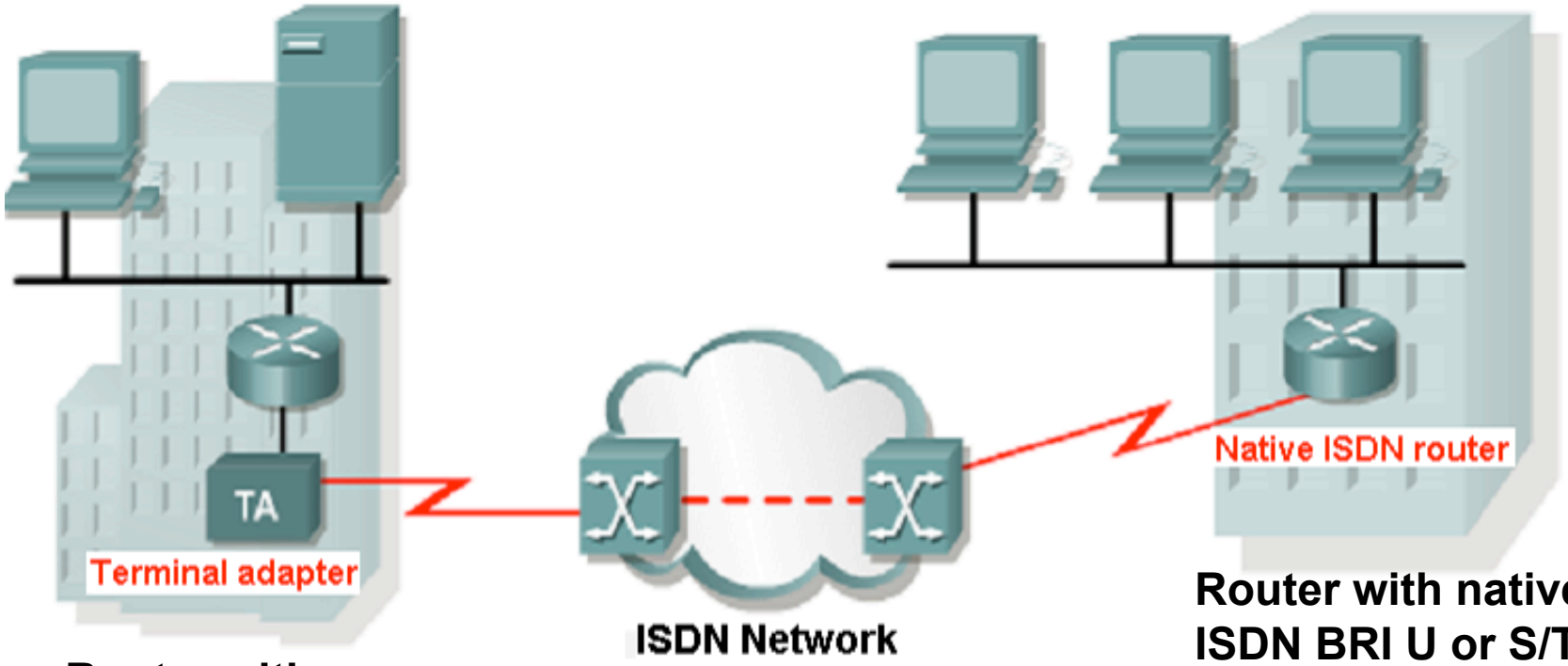


WAN built with intermittent connections using a modem and the voice telephone network.

ISDN



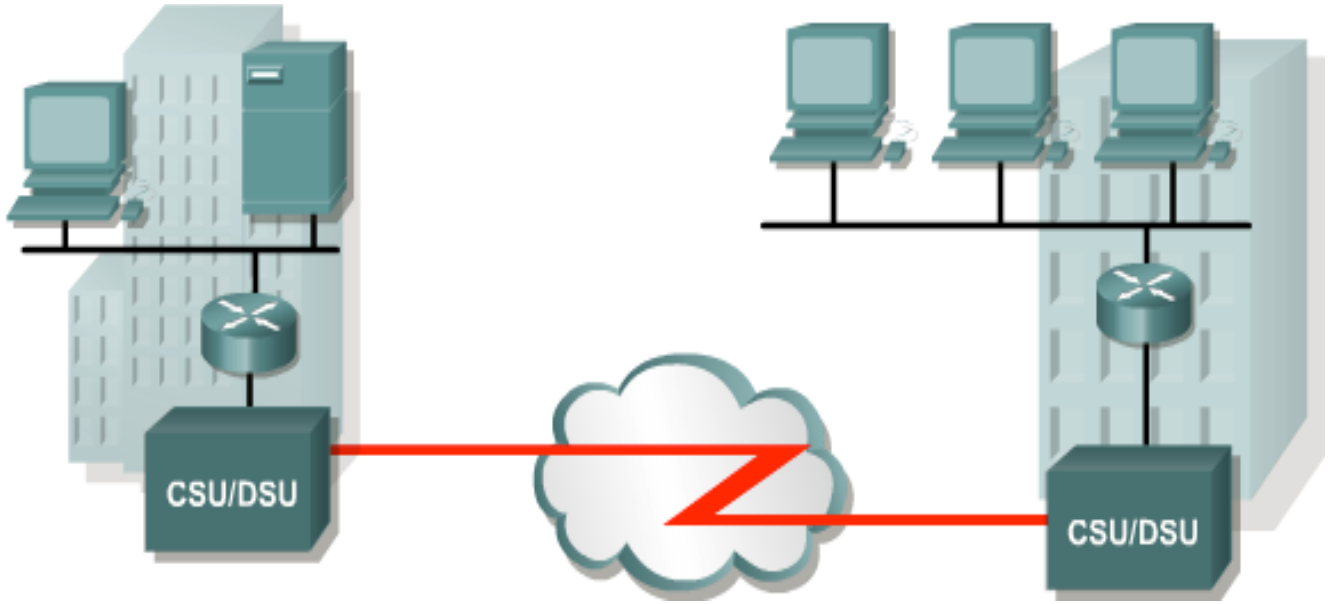
ISDN



Router with standard serial interface, connected to a terminal adapter

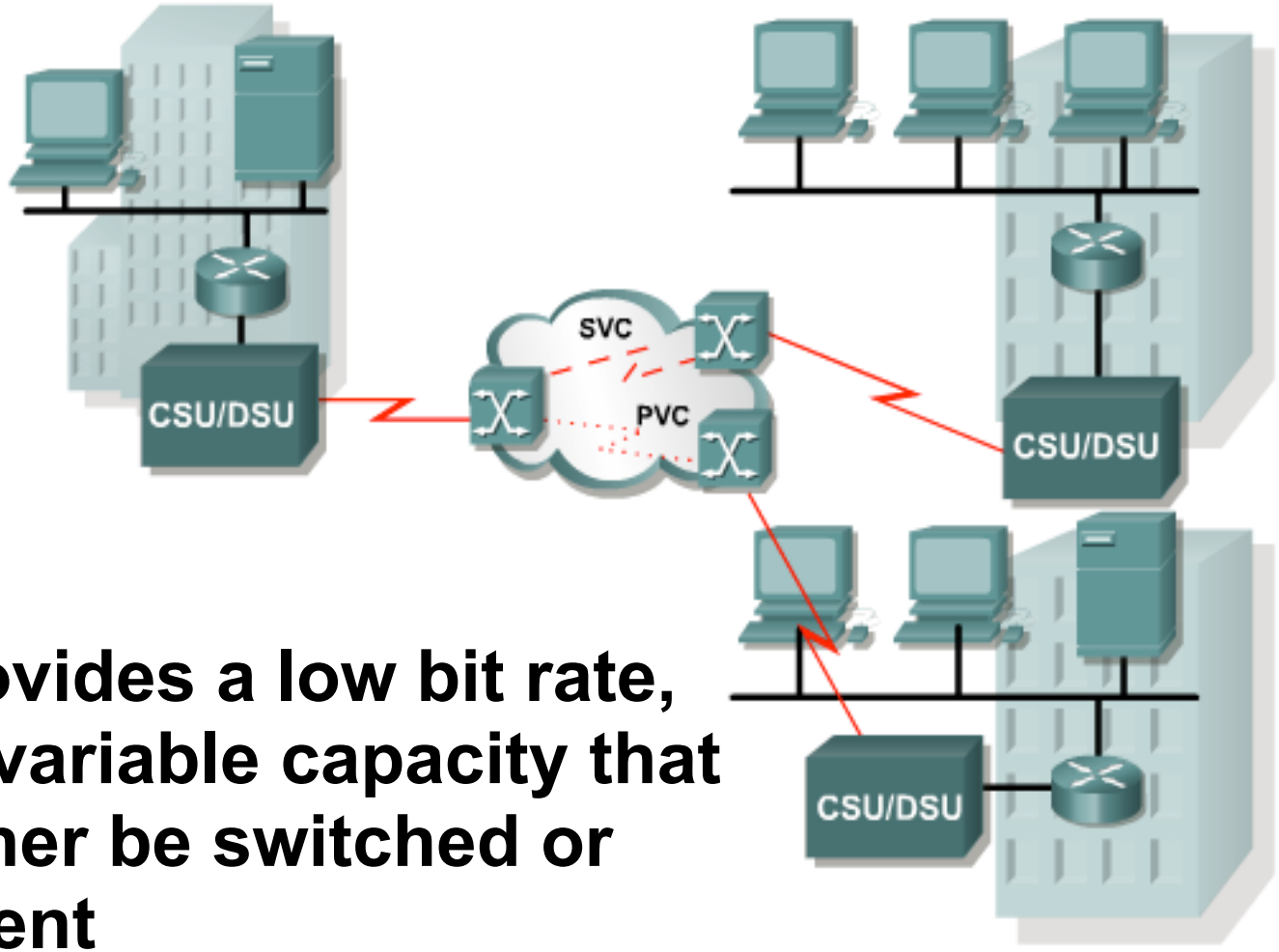
Router with native ISDN BRI U or S/T interface or PRI

Leased Line



- **Leased lines are not only used to provide direct point-to-point connections between Enterprise LANS, they can also be used to connect individual branches to a packet switched network.**

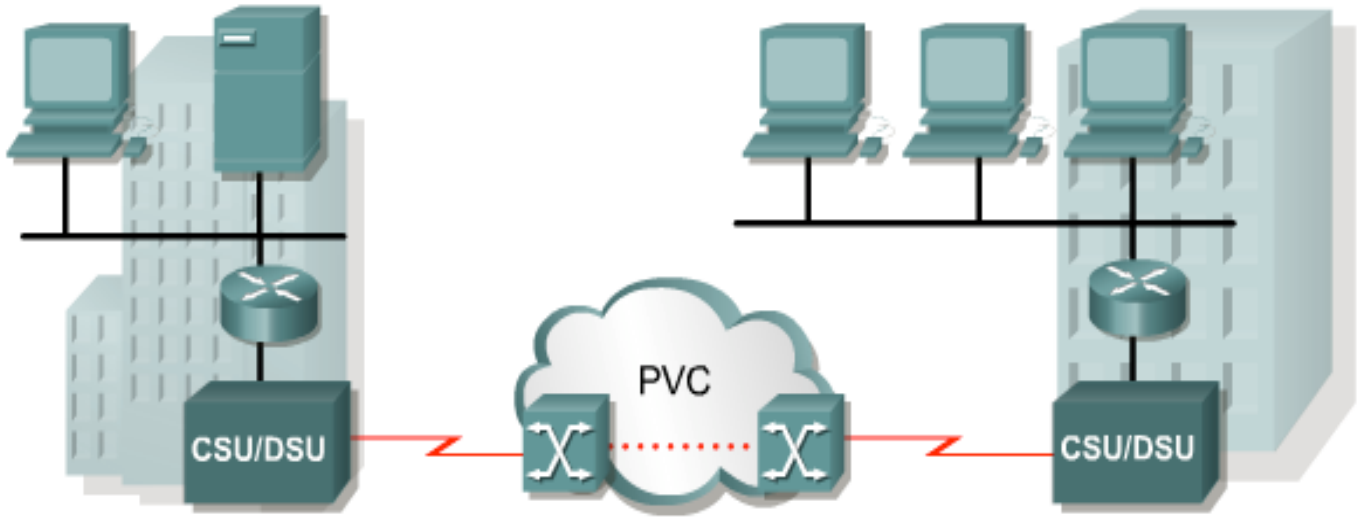
WAN with X.25



- X.25 provides a low bit rate, shared-variable capacity that may either be switched or permanent

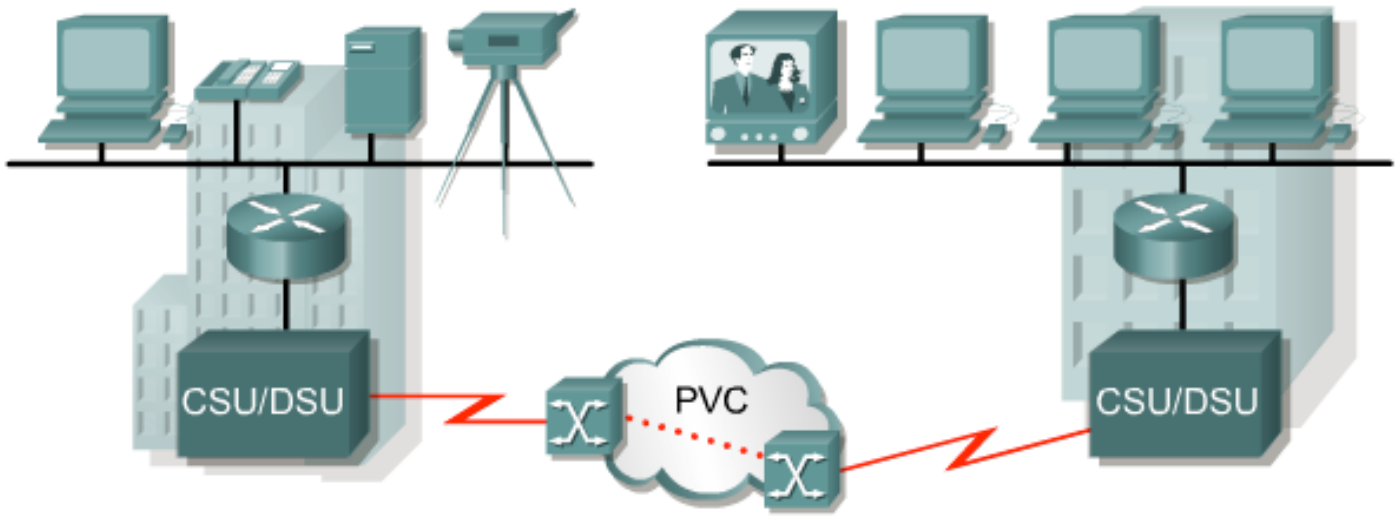
Frame Relay

- Most Frame Relay connections are based on PVCs rather than SVCs.
- It implements no error or flow control. This leads to reduced latency.
- Frame Relay provides permanent shared medium bandwidth connectivity that carries both voice and data traffic.



ATM

- **Asynchronous Transfer Mode (ATM) is a technology capable of transferring voice, video, and data through private and public networks.**
- **It is built on a cell based architecture rather than on a frame-based architecture.**

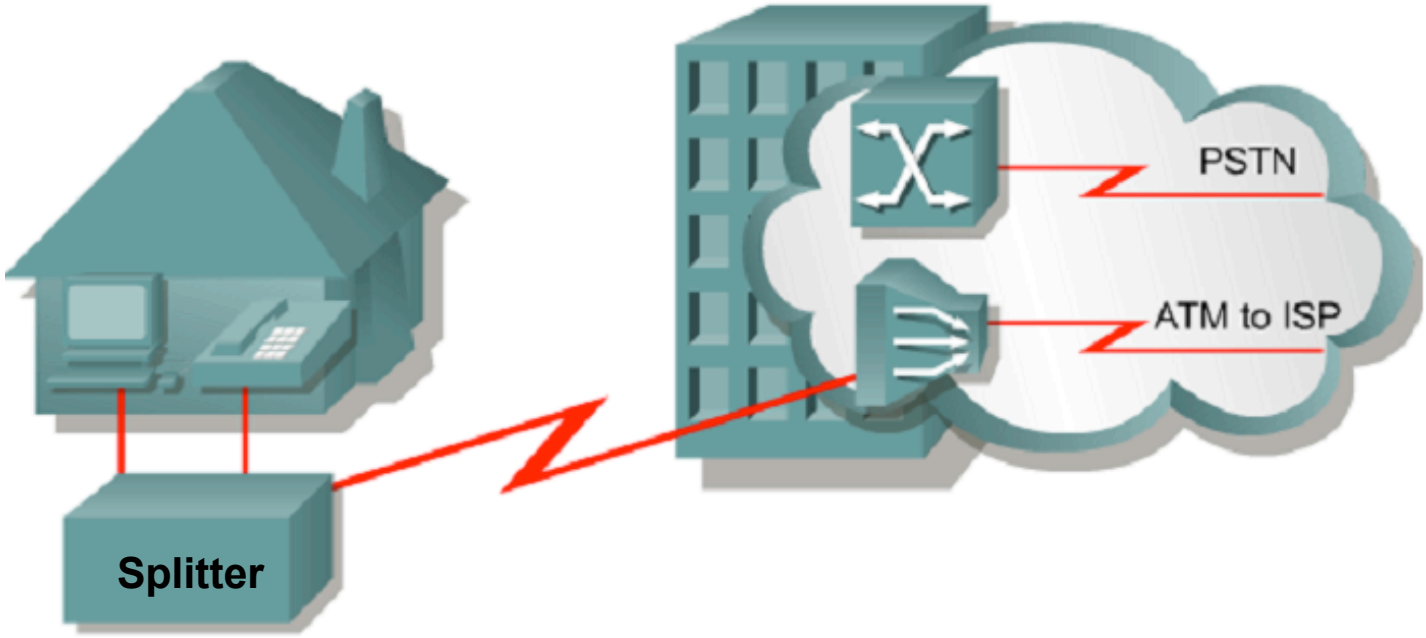


DSL

Service	Download	Upload
ADSL	1.5 M - 8.192 M	16 K - 640 K
SDSL	1.544 M - 2.048 M	1.544 M - 2.048 M
HDSL	1.544 M - 2.048 M	1.544 M - 2.048 M
IDSL	144 K	144 K
RADSL	64 K - 8.192 M	16 M - 768 M
CDSL	1 M	16 K -160 K

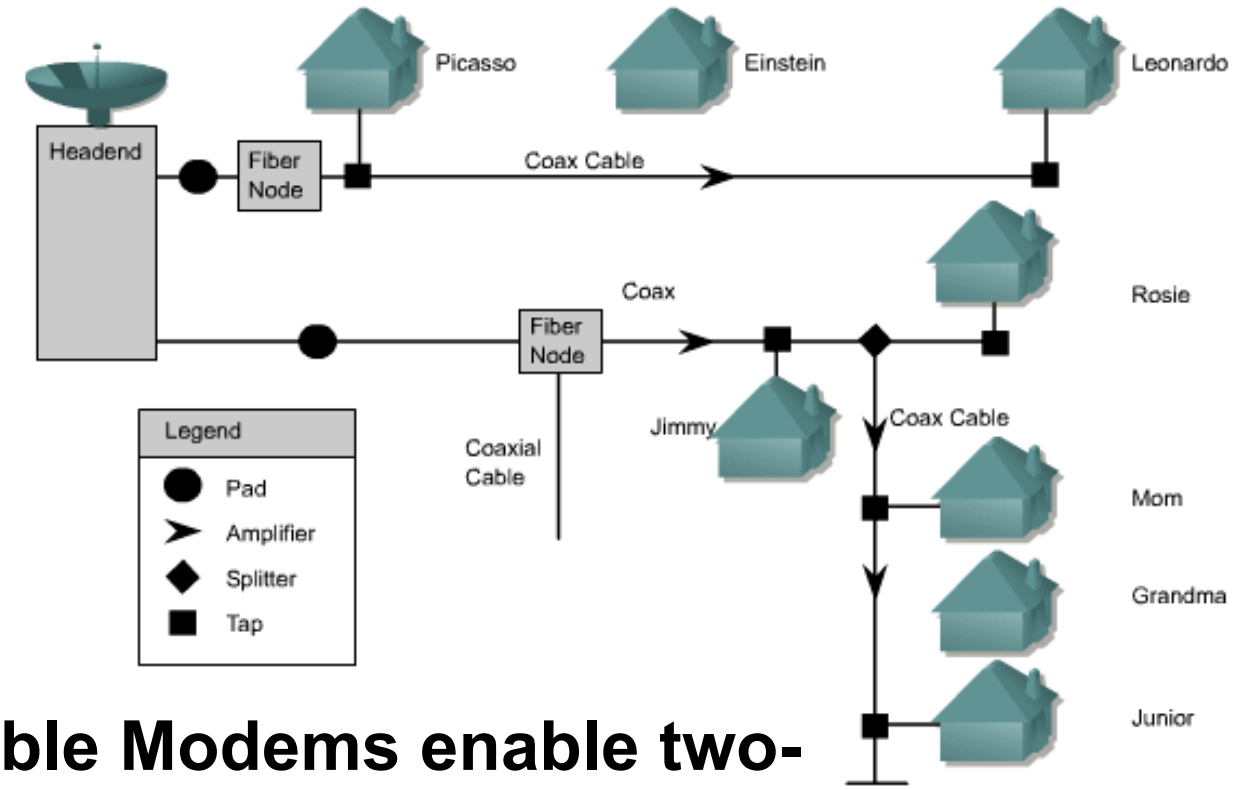
- **DSL uses existing twisted-pair telephone lines to transport high-bandwidth data**
- **DSL service is considered broadband, as it uses multiple frequencies within the same physical medium to transmit data**

ADSL Technology



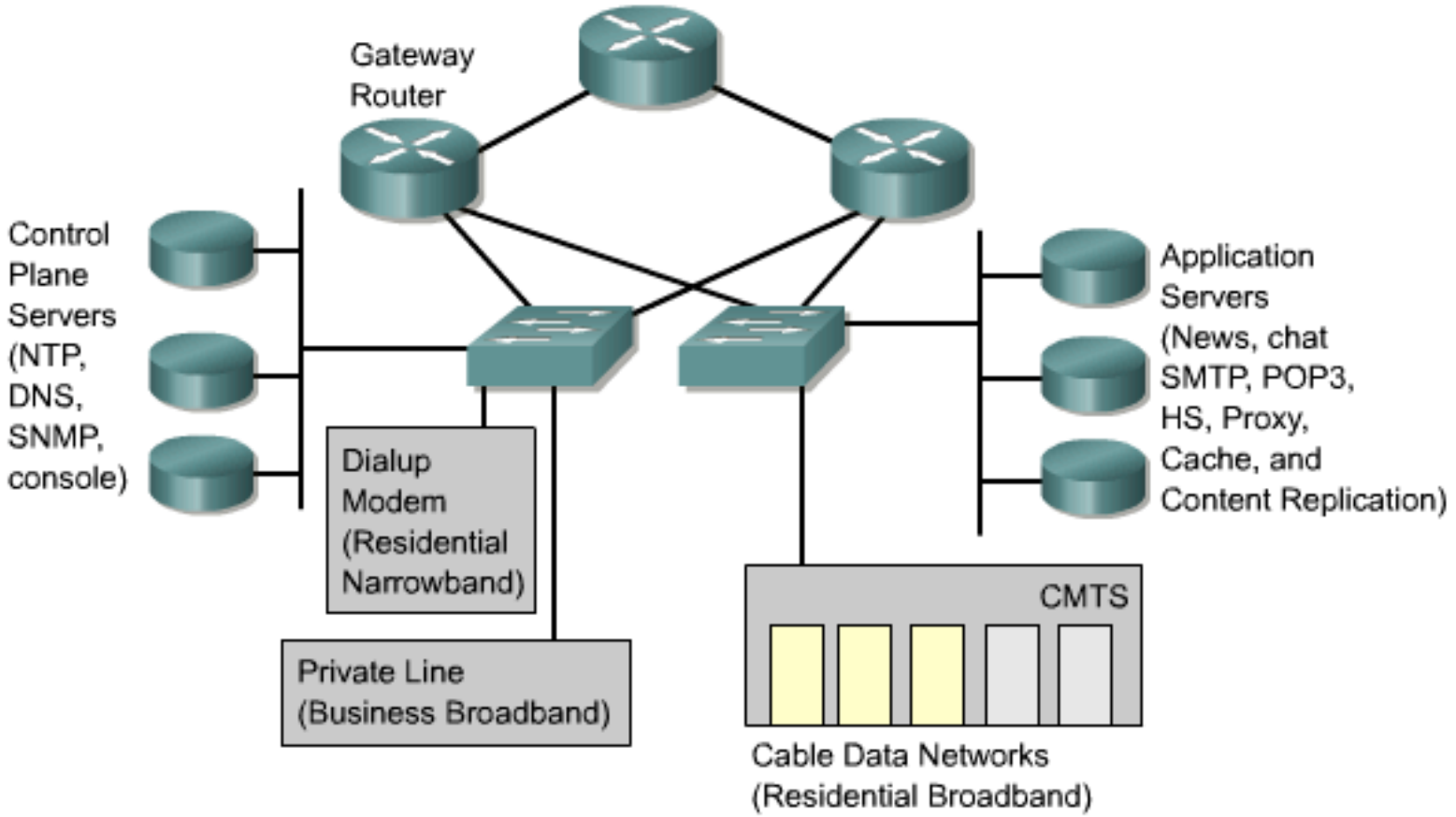
- The local loop connects the splitter to the DSLAM
- DSLAM connected to ISP using ATM technology
- Voice and data use separate frequency ranges (voice 0-4Khz, data 20Khx – 1Mhz)

Cable Modem

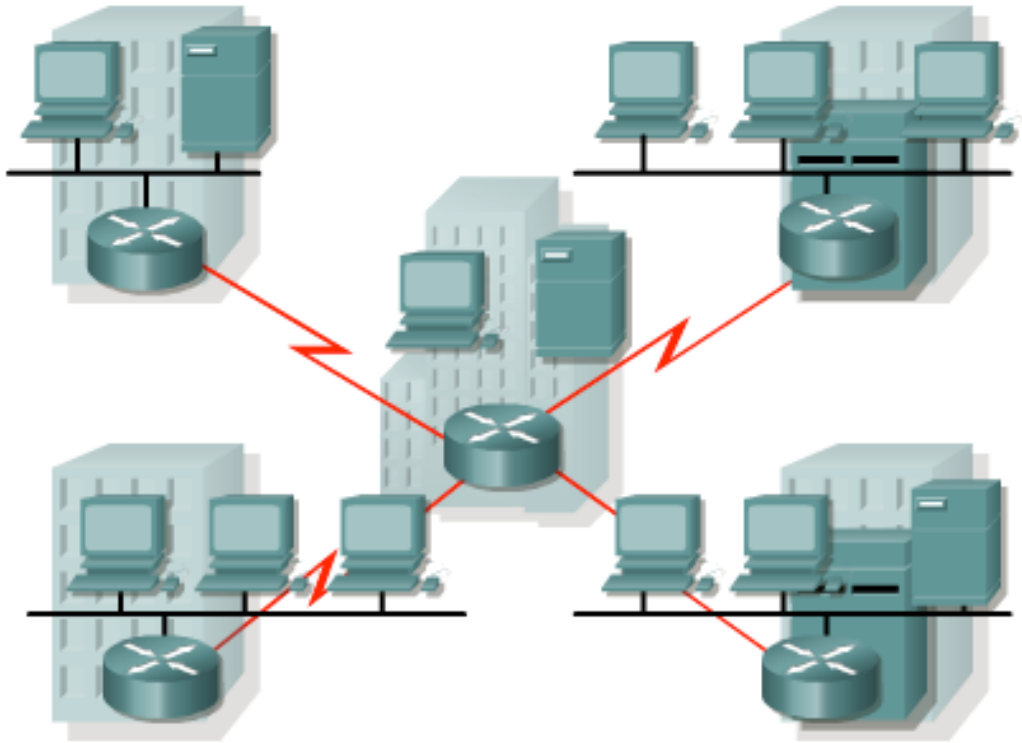


- **Enhanced Cable Modems enable two-way. High speed data transmissions using the same coaxial lines that transmit cable television.**

Cable Data Network Architecture

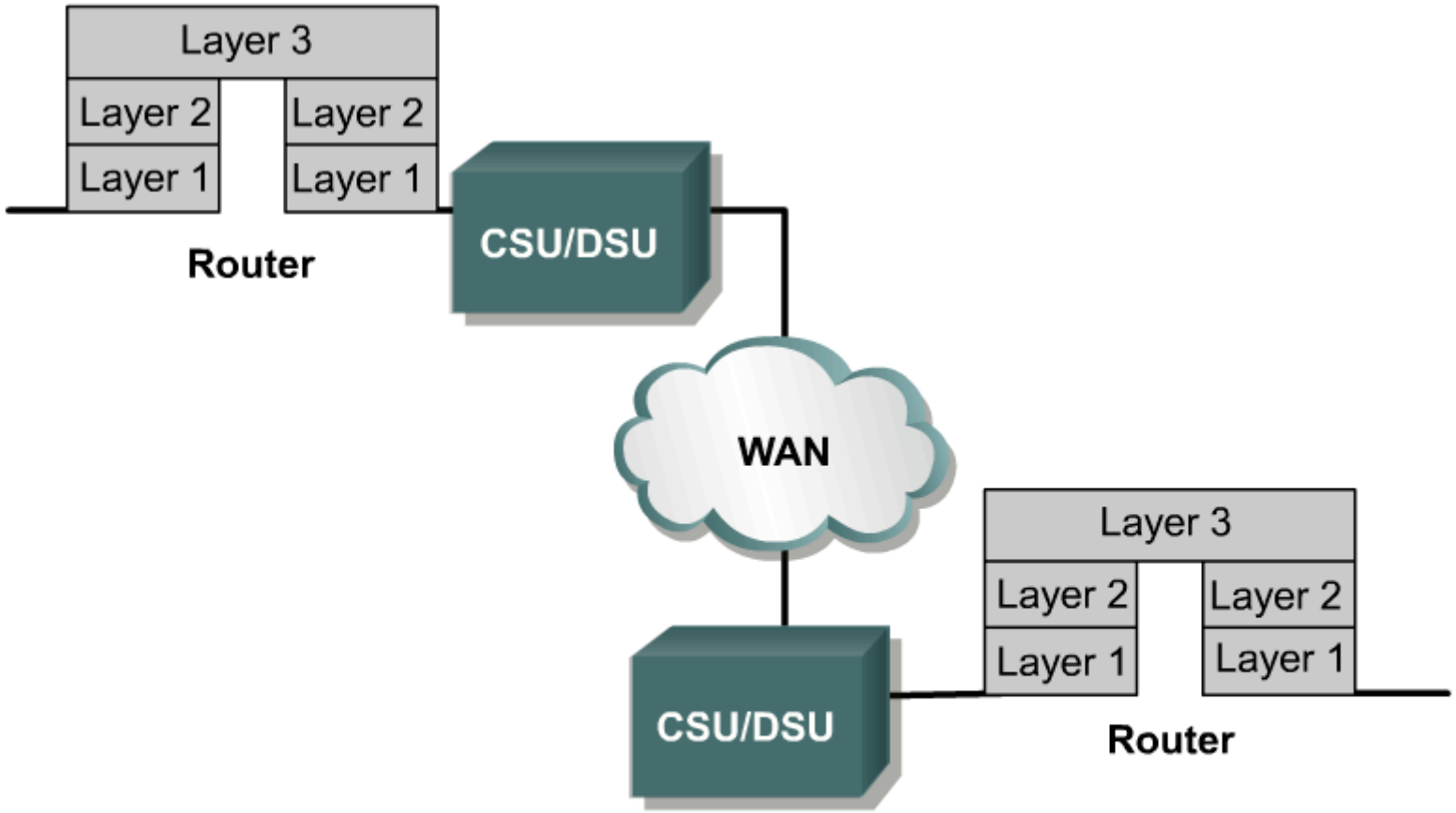


Modern WAN



LANs separated by distance are linked by data communications lines and routers.

WANs Operate at the Lower Three Levels of the OSI Model



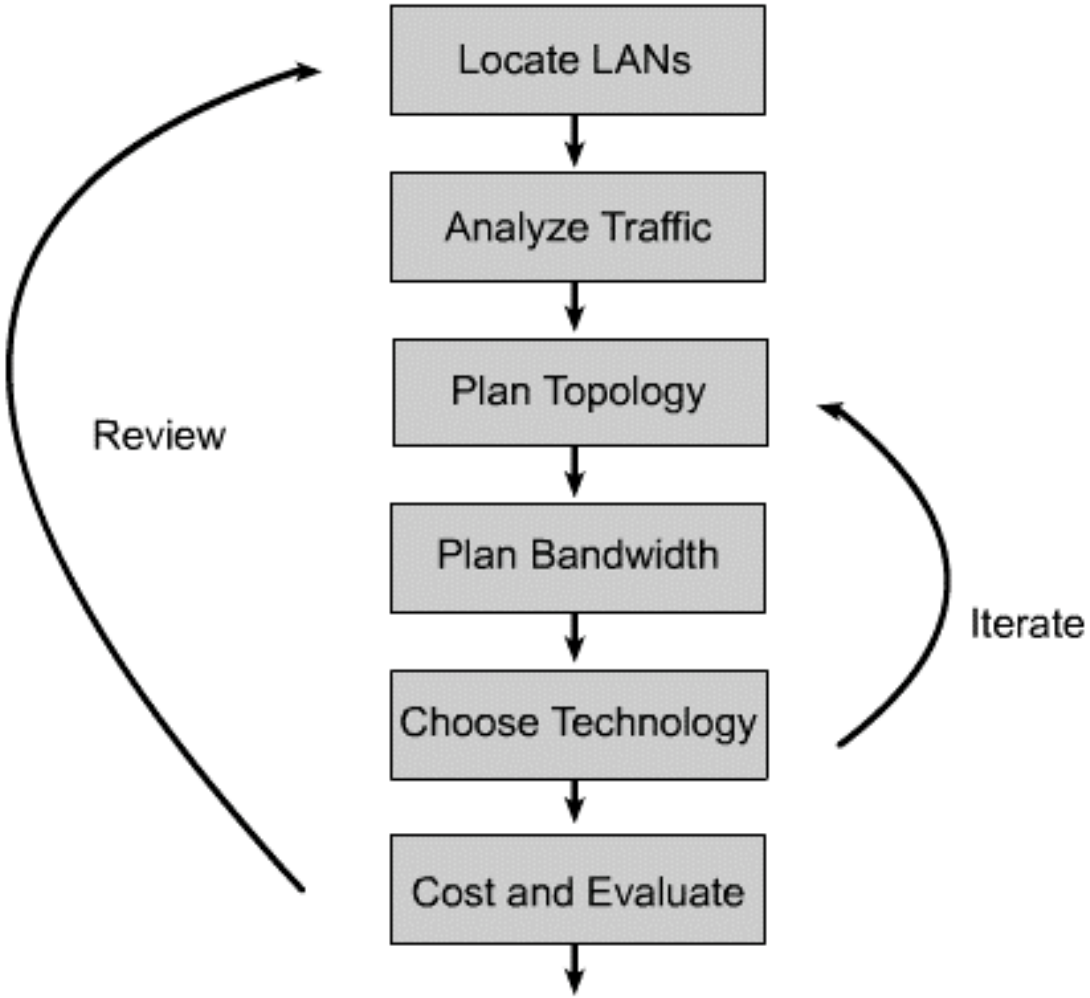
WANs operate at the lower three levels of the OSI protocol stack.

Comparing WAN Traffic Types

Traffic	Latency	Jitter	Bandwidth
Voice	Low	Low	Medium
Transaction data (for example, SNA)	Medium	Medium	Medium
Messaging (e-mail)	High	High	High
File transfer	High	High	High
Batch data	High	High	High
Network management	High	High	Low
Videoconferencing	Low	Low	High

Some WAN traffic types with tolerance to latency and jitter, along with bandwidth requirements.

Steps In WAN Design



Three-Layer Design Model

- The links connecting the various sites in an area that provide access to the enterprise network are called the access links or access layer of the WAN.
- Traffic between areas is distributed by the distribution links, and is moved onto the core links for transfer to other regions, when necessary.

Advantages of the Hierarchical Approach

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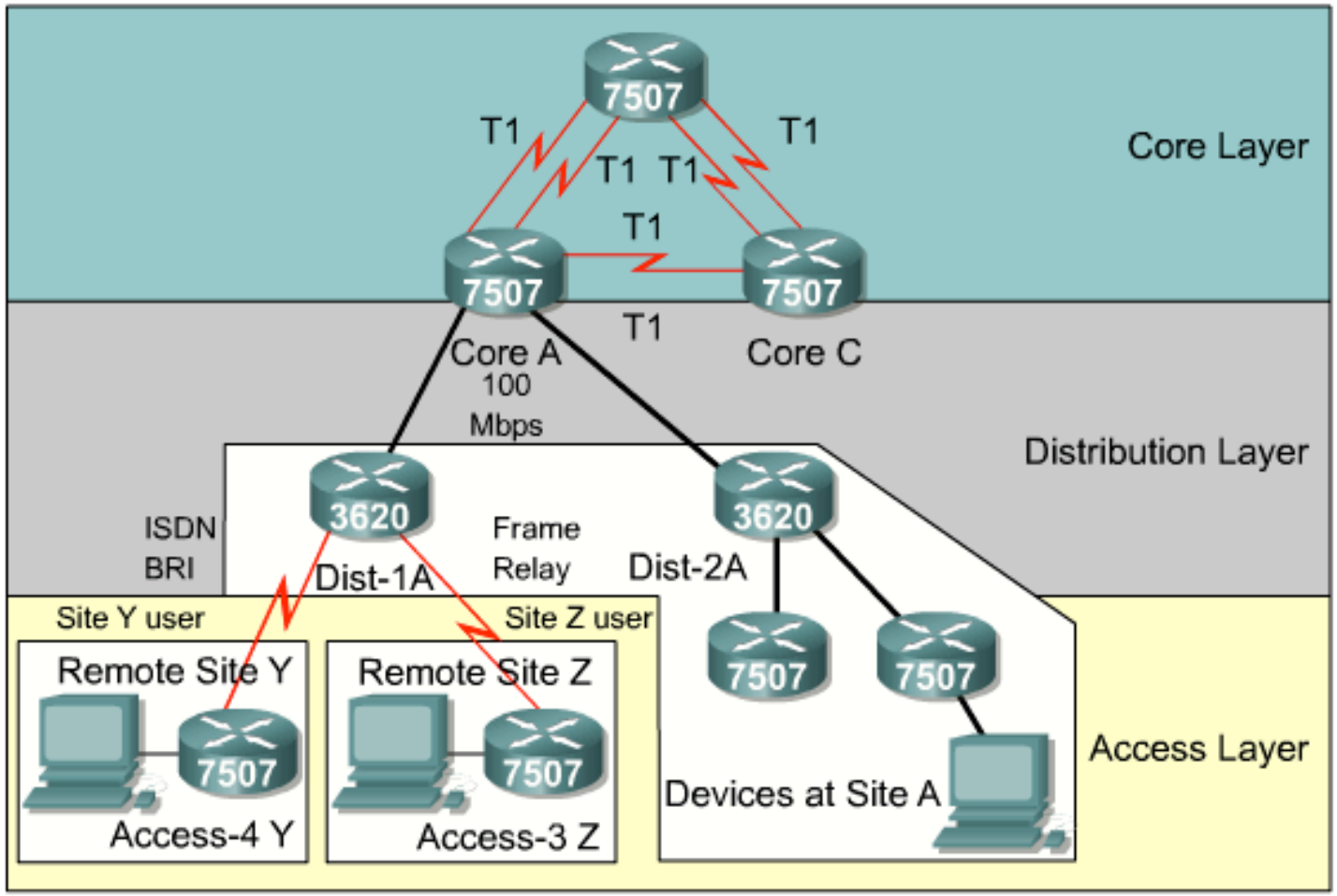
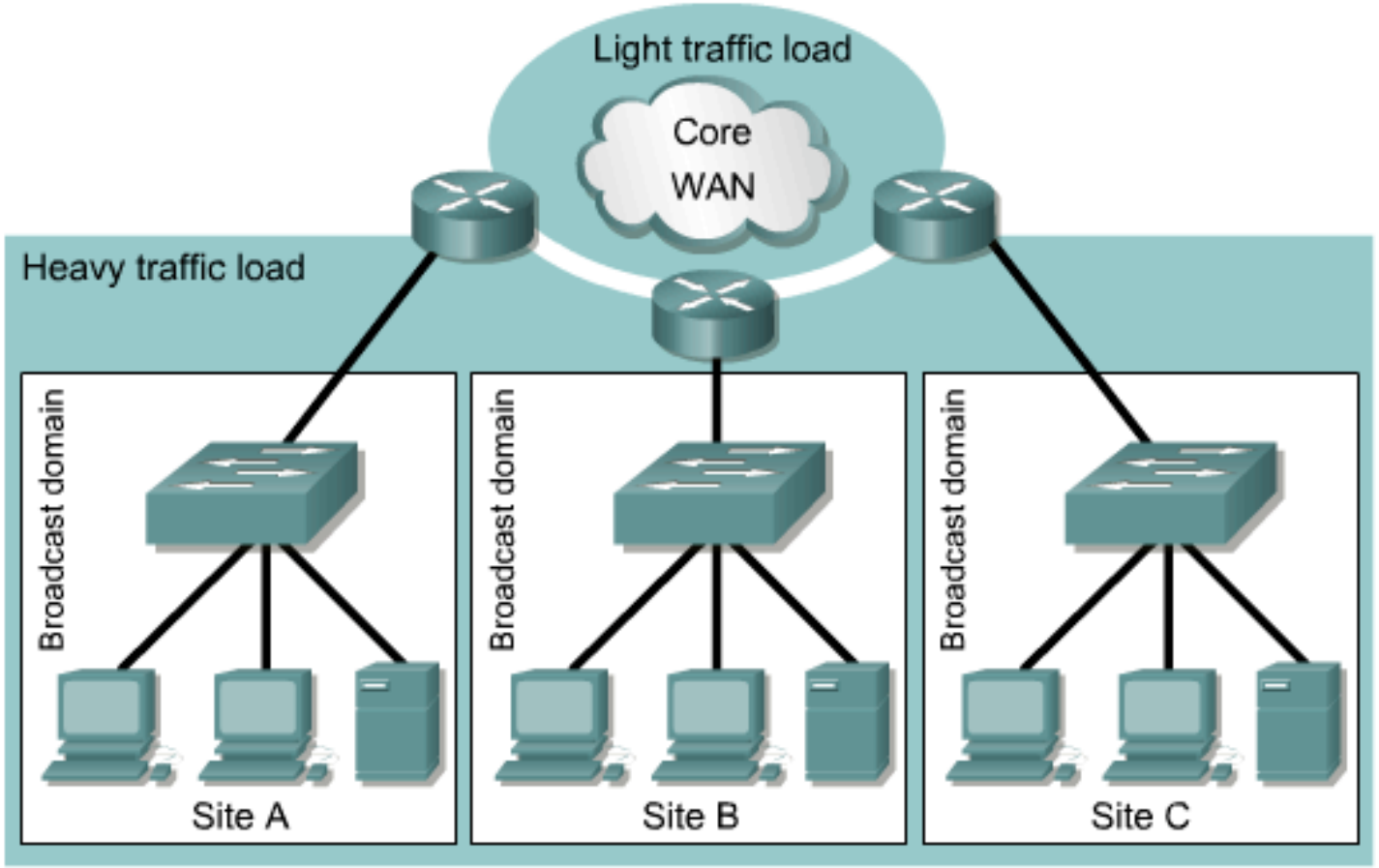
- Scalability: networks can grow without sacrificing control or manageability
- Ease of Implementation: clear functionality at each layer
- Ease of troubleshooting: Isolation of problems in the network is easier
- Predicatability network modelling and caapacity plannng easier
- Protocol Support: mixing current and future applications and protocols is easier
- Manageability: all the above improve the manageability of the network

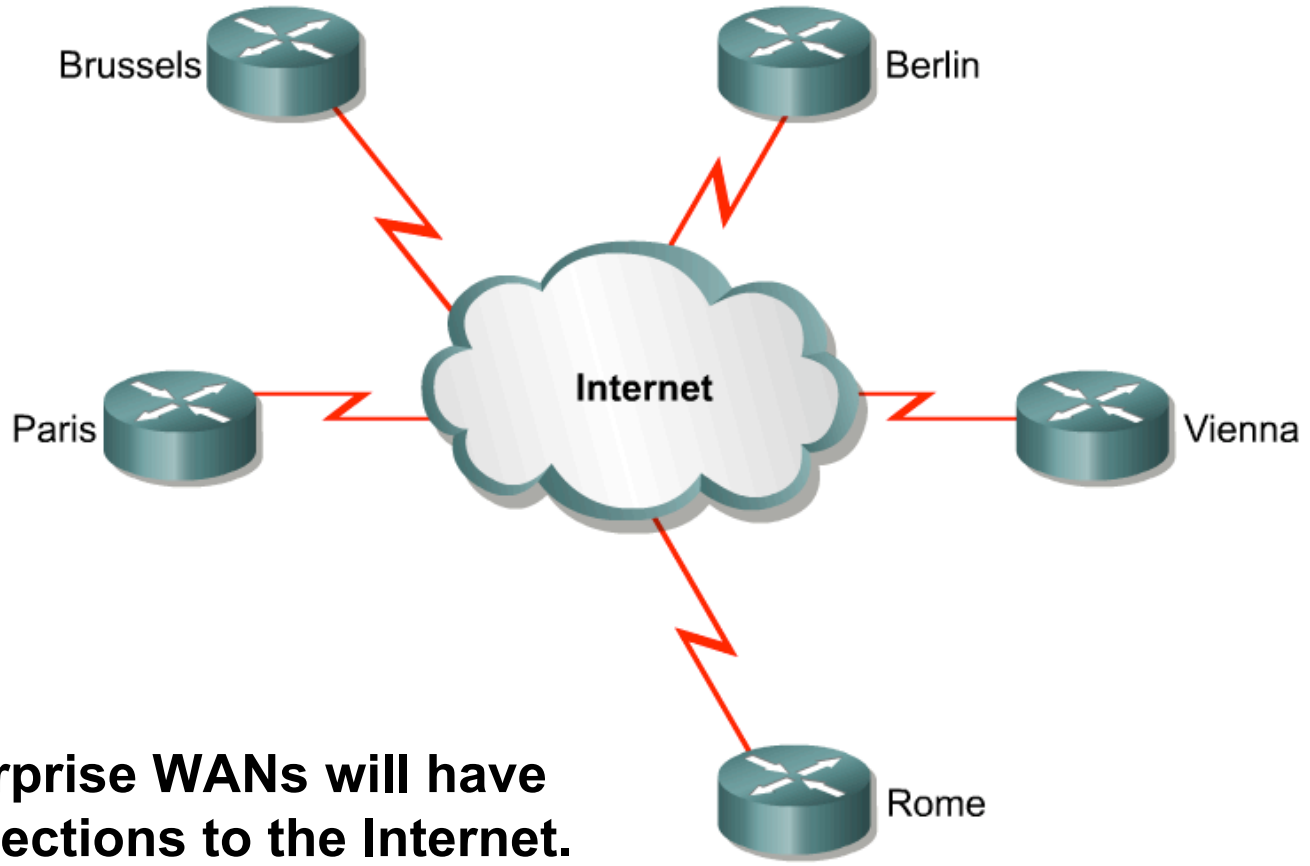
Internet for WAN Connectivity



One-Layer Hierarchy

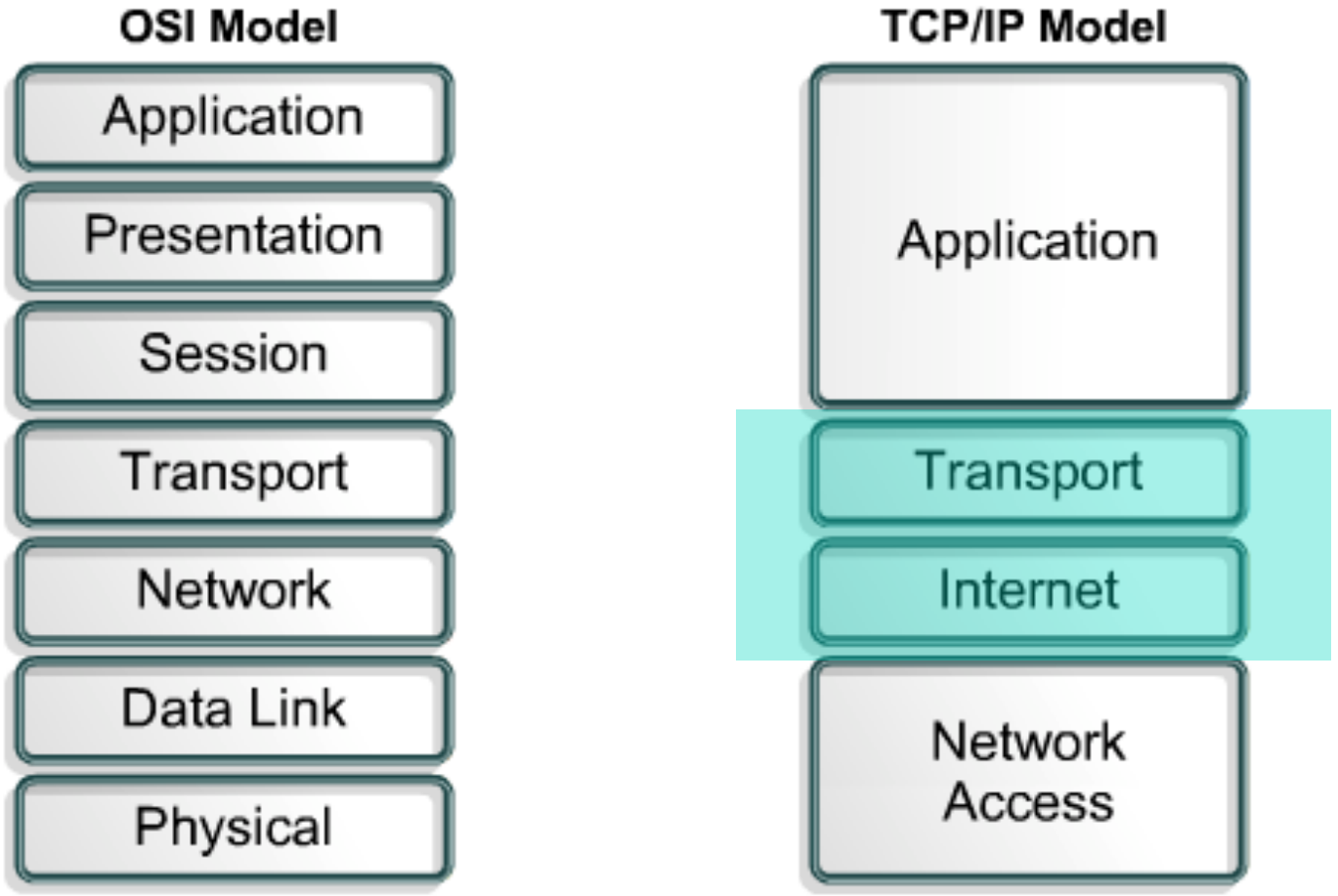


Using the Internet as an Enterprise WAN

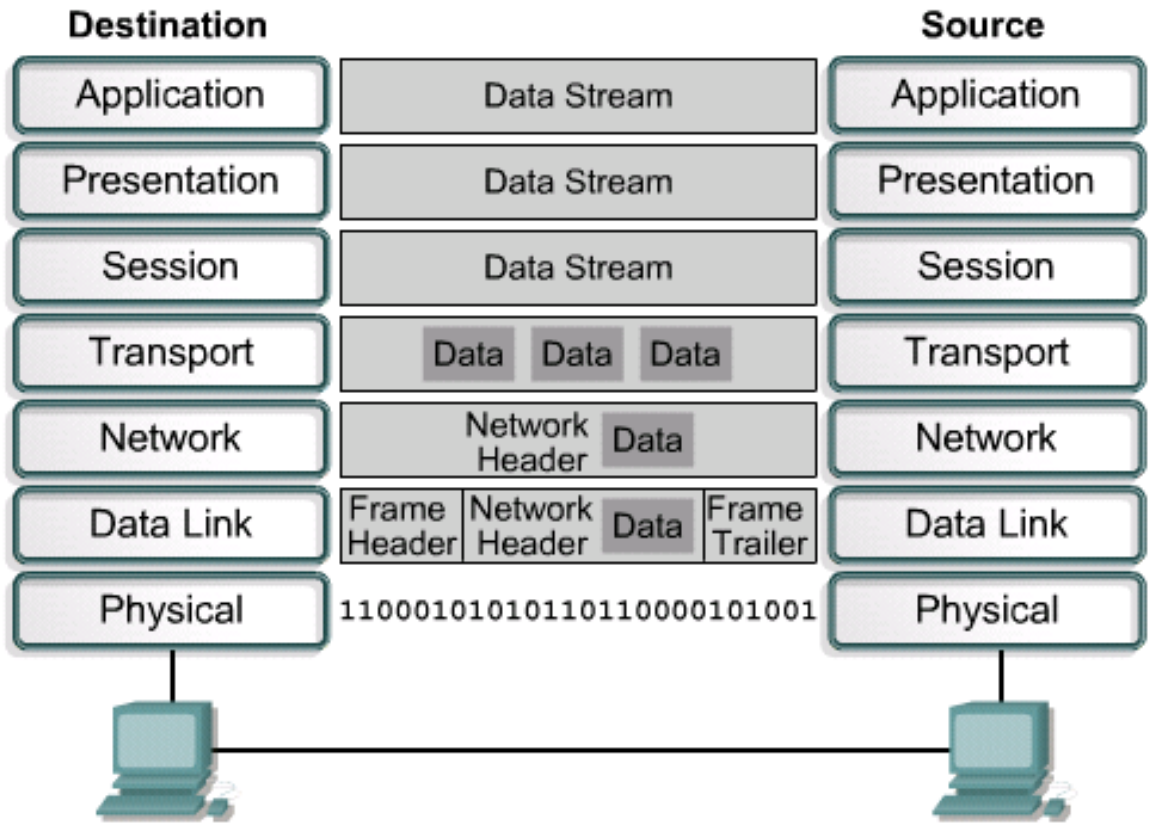


- **Enterprise WANs will have connections to the Internet.**
- **This poses security problems but also provides an alternative for inter-branch traffic.**
- **VPN technologies can solve security issues**

TCP/IP Model



Encapsulation



Summary

Summary

- A WAN is a data communications network that operates beyond the geographic scope of a LAN.
- WANs use the OSI reference model, but focus mainly on Layer 1 and Layer 2. WAN standards typically describe both physical layer delivery methods and data link layer requirements, including physical addressing, flow control, and encapsulation.
- Packet-switched networks were developed to overcome the expense of public circuit-switched networks and to provide a more cost-effective WAN technology.
- WAN technologies and standards include: ISDN, Frame Relay, ATM, T1, HDLC, PPP, POST, BRI, PRI, X.25, and DSL.
- In designing the WAN, it is necessary to know what data traffic must be carried, its origin, and its destination. WANs carry a variety of traffic types with varying requirements for bandwidth, latency, and jitter.
- Designing a WAN essentially consists of the following:
  - Selecting an interconnection pattern or layout for the links between the various locations
  - Selecting the technologies for those links to meet the enterprise requirements at an acceptable cost